

Appendix F

Classification Examples

This appendix contains classification examples using the analytical classification procedure. Refer to *Chapter 3* for a detailed discussion of the equations.

NOTATIONS

F-1. This appendix contains examples for classifying a bridge using the analytical classification procedure. The following notations are used in this appendix:

A	= net area of the section, in square inches, or compression area of the arch ring segment, in square inches
A_{angles}	= angle area
$A_{angles_{net}}$	= net angle area
A_b	= area of one reinforcing bar
A_c	= area of the concrete resisting compression, in square inches
A_f	= cross-sectional flange area, in square inches
$A_{f(1)}$	= area of girder flange, in square inches
A_{fa}	= area of angles connecting the flange to the web on a girder, in square inches
$A_{flanges}$	= flange area
A_g	= gross cross-sectional area, in square inches
A_{girder}	= girder area
A_n	= net area of the bottom truss chord, in square inches
A_p	= cross-sectional area of a bar or tendon, in square inches
A_{plates}	= plate area
$A_{plates_{net}}$	= net plate area
A_{ps}	= total area of the prestressed steel in the bottom half of the beam at midspan, in square inches
A_{rivets}	= rivet area
A_s	= area of bearing plates, square inches
A_{st}	= area of tension steel, in square inches
A_t	= total area of the tension chord of one truss, in square inches
A_v	= effective shear area, in square inches
A_w	= area of the web, in square inches
A_{web}	= web area

b	= arch-rib width, in inches
b'	= beam width, in inches
b''	= effective flange width, in inches
b_e	= effective slab width, in feet
b_f	= flange width, in inches
b_r	= curb-to-curb roadway width, in feet
b_s	= stringer or slab width, in inches
c	= allowable compressive force, in kips
C	= reduction factor
C_c	= buckling coefficient
C_v	= minimum spacing between vehicles in adjacent lanes, in feet
d	= stringer depth, in inches
d'	= distance from the top of the beam to the center of the tension steel, in inches
d_f	= depth of fill above the arch ring, in feet
d_i	= inside web depth of the girder measured between the top and bottom pieces
d_o	= depth of the compression zone, in inches
d_{ps}	= distance from the top of the slab to the center of the prestressed steel, in inches
d_s	= distance from the top of the slab to the center of the nonprestressed steel, in inches
d_w	= total depth of the girder, in inches
f'_c	= 28-day strength of the concrete, in ksi
f_{DL}	= dead-load compression for steel, in ksi
f_{ps}	= average stress in the prestressed steel at the design load, in ksi
f_{pu}	= ultimate strength of the prestressed steel, in ksi
f_{sy}	= yield strength of the nonprestressed reinforcing steel, in ksi
f_t	= allowable tension in the suspended cable, in ksi
F'	= smaller of tensile or compressive force on the chords, in kips
F_a	= allowable axial compression, in ksi
F_b	= maximum allowable bending stress of the member, in ksi
F_c	= allowable axial compressive stress, in ksi
F_{DL}	= stress induced in the steel by the dead-load moment, in ksi
F_{LL}	= allowable live-load stress for steel or concrete, in ksi
F_t	= allowable tension on the bottom chord, in ksi
F_v	= maximum allowable shear stress, in ksi
F_y	= yield strength of the reinforcing steel, in ksi
H_{DL}	= redundant horizontal thrust, in ksi
H_{LL}	= horizontal-loading component, in kips
I_c	= moment of inertia for the combined beam section, in inches
I_o	= moment of inertia for geometric portions of the beam, in inches ⁴

I_s	= moment of inertia for the combined beam section, in inches ⁴
K	= material constant
L	= span length, in feet
L_{eff}	= equivalent span length
L_x	= unbraced length in the vertical direction, in inches
L_y	= unbraced length in the horizontal direction, in inches
m	= moment capacity of a component, in kip-feet
m_{DL}	= dead-load moment per component, in kip-feet
m_{LL}	= live-load moment per component, in kip-feet
M	= total moment capacity, in kip-feet
M_{LL}	= total live-load moment per lane, in kip-feet
N_1	= maximum effective number of stringers for one-lane traffic
$N_{1,2}$	= the smaller value of N_1 and N_2
N_2	= maximum effective number of stringers for two-lane traffic
N_S	= total number of stringers in the span
N_t	= number of trusses
P_{cLL}	= live-load capacity of the bridge, in kips
P_e	= effective load per track or line of wheels, in kips
P_{LL}	= live-load capacity of the bridge, in kips
r	= minimum radius of gyration of the member, in inches
r_m	= modular ratio
r_x	= radius of gyration for the x axis
r_y	= radius of gyration for the y axis
R	= rise of the arch, in feet
R_{ps}	= prestressed reinforcement ratio
R_r	= reinforcement ratio
R_s	= steel ratio, in square inches
S	= section modulus, in cubic inches
S_b	= lateral-brace spacing, in feet
$S_{\text{composite}}$	= section modulus of the composite section, in cubic inches
S_e	= center-to-center track or wheel spacing, in feet
S_f	= center-to-center floor-beam spacing, in feet
S_g	= center-to-center girder spacing, in feet
S_{girder}	= section modulus of the girder
S_r	= rib spacing, in feet
S_s	= stringer spacing, in feet
S_{steel}	= section modulus of steel, in cubic inches
S_t	= center-to-center truss spacing, in feet
S_{T-B}	= center-to-center T-beam spacing, in inches
t	= thickness of the arch ring
t_d	= average deck thickness, in inches

t_f	= flange thickness, in inches
T	= tensile force on the bottom chord, in kips
T_{DL}	= dead-load component of the cable capacity
T_1	= tracked vehicles, one-lane traffic
T_2	= tracked vehicles, two-lane traffic
T_{LL}	= live-load capacity of the suspended cable, in kips
v	= shear capacity per member, in kips
v_{DL}	= dead-load shear per member, in kips
v_{LL}	= live-load shear capacity per member, in kips
V_{LL}	= allowable vehicle shear for one lane, in kips
w_b	= uniform dead load due to lateral bracing of floor stringers, in kpf
w_{DL}	= dead-load capacity per foot of member, in kips
w_{FS}	= uniform dead load on the girder due to the deck, stringers, and floor beams, in kpf
w_g	= uniform dead load due to the girder itself, in kpf
W_1	= wheeled vehicles, one-lane traffic
W_2	= wheeled vehicles, two-lane traffic
W_{DL}	= total dead-load weight per foot per member, in kips
W_{LL}	= allowable live-load per member, in kips
x	= impact factor
x_r	= reduction factor
\bar{y}	= distance from the baseline to the neutral axis of the simple shape, in inches
y_c	= centroid of the composite section, in inches

TIMBER-STRINGER BRIDGE

F-2. In this example, *Table F-1*, pages F-5 and F-6, shows the procedure for classifying a timber-stringer bridge and *Table F-2*, page F-6, contains a classification summary. *Figure F-1*, page F-7, shows a sample bridge-reconnaissance report for a timber-stringer bridge. Information from an on-site inspection is as follows:

- The bridge is in good condition.
- All members are in good condition.
- The piling and abutment end beams have been treated to reduce deterioration. Therefore, substructure is not rated.
- The bridge is about two years old.
- Each of the three spans are constructed identically, so the longer (17-foot) span will be classified as the weakest span.
- The timber species is dense, select-structural Douglas fir.
- The horizontal splits are no longer than 6 inches.

Table F-1. Classification Procedure for a Timber-Stringer Bridge

Step	Equation/Procedure	Consideration	Computation
1	Allowable stress (dense, select-structural Douglas fir)	para 3-46 <i>Table C-1</i>	$F_b = 1.9 \text{ ksi (stringers)}$ $= (1.33)(1.9) = 2.53 \text{ ksi}$
2	Number of effective members	para 3-32, 3-49 <i>Table 3-3</i>	$S_s = 3 \text{ ft, nail-laminated deck } (\geq 6 \text{ in})$: <u>One lane:</u> $N_1 = \frac{10}{S_s} = \frac{10}{3} = 3.33$ <u>Two lanes:</u> $N_2 = \frac{8.5}{S_s} = \frac{8.5}{3} = 2.83$
3	Equivalent span length	para 3-42	$L_{eff} = (0.7)(17 \text{ ft}) = 11.9 \text{ ft (interior span)}$
4	$m = \frac{F_b S}{I_2}$	para 3-34, 3-49 (eq 3-2) Use <i>Tables C-4 and C-5</i> to find S.	$S = 432 \text{ in}^3$ $m = \frac{(2.53)(432)}{12} = 91.08 \text{ kip-feet}$
5	Total dead-load weight of the bridge components	para 3-29, 3-35 Compute for an average 1-ft length of bridge span.	$W_{DL} = (9)\left(\frac{8 \times 18}{144}\right)(32) + \left(6 \times \frac{1}{12}\right)(50)(24)$ $+ \left(2 \times \frac{1}{12}\right)(150)(24) + 100 = 1,588 \text{ lb/ft}$ $W_{DL} = \frac{1,588 \text{ lb/ft}}{1,000} = 1.59 \text{ kpf}$
6	$w_{DL} = \frac{W_{DL}}{N_S}$	para 3-29 (eq 3-1)	$w_{DL} = \frac{W_{DL}}{N_S} = \frac{1.59 \text{ kpf}}{9} = 0.176 \text{ kpf}$
7	$m_{DL} = \frac{w_{DL}L^2}{8}$ $L = L_{eff} = 11.9 \text{ ft}$	para 3-35 (eq 3-3)	$m_{DL} = \frac{(0.176)(11.9)^2}{8} = 3.12 \text{ kip-feet}$
8	$m_{LL} = \frac{m - m_{DL}}{1+x}$ $x = 0 \text{ (timber)}$	para 3-36 (eq 3-4)	$m_{LL} = \frac{91.08 - 3.12}{1} = 87.96 \text{ kip-feet}$
9	$M_{LL} = N_{1,2}m_{LL}$	para 3-38 (eq 3-5)	<u>One lane:</u> $M_{LL} = (3.33)(87.96) = 292.91 \text{ kip-feet}$ <u>Two lanes:</u> $M_{LL} = (2.83)(87.96) = 248.93 \text{ kip-feet}$
10	Moment classification	Appendix B <i>Table B-2 or Figures B-1, B-2</i> para 3-43 $L = 11.9 \text{ ft}$	<u>One lane:</u> W150 <u>Two lanes:</u> W150 T150 T150
11	Allowable shear stress	para 3-46 <i>Table C-1</i>	$F_v = 0.085 \text{ ksi (stringers)}$ $= (1.33)(0.085) = 0.113 \text{ ksi}$
12	Effective shear area	<i>Table C-4</i>	$A_v = 96 \text{ in}^2$
13	$v = A_v F_v$	para 3-51 (eq 3-6)	$v = (96)(0.113) = 10.85 \text{ kips}$

Table F-1. Classification Procedure for a Timber-Stringer Bridge (continued)

Step	Equation/Procedure	Consideration	Computation
14	$v_{DL} = \frac{W_{DL}L}{2} \left(1 - \frac{d}{6L}\right)$	para 3-52 (eq 3-7)	$v_{DL} = \frac{(0.176)(11.9)}{2} \left(1 - \frac{18}{(6)(11.9)}\right) = 0.783 \text{ kips}$
15	$v_{LL} = v - v_{DL}$	para 3-53 (eq 3-8)	$v_{LL} = 10.85 - 0.783 = 10.07 \text{ kips}$
16	$V_{LL} = 5.33v_{LL} \left[\frac{I}{0.6 + \left(\frac{2}{N_{I,2}} \right)} \right]$	para 3-54 (eq 3-9)	<u>One lane:</u> $V_{LL} = (5.33)(10.07) \left(\frac{I}{0.6 + \frac{2}{3.33}} \right) = 44.71 \text{ kips}$ <u>Two lanes:</u> $V_{LL} = (5.33)(10.07) \left(\frac{I}{0.6 + \frac{2}{2.83}} \right) = 41.07 \text{ kips}$
17	Shear classification	Appendix B Table B-2 or Figures B-3, B-4 $L = 11.9 \text{ ft}$	<u>One lane:</u> W43 T45 <u>Two lanes:</u> W35 T41
18	Deck classification (laminated plank)	para 3-57, 3-58, 3-59 Figure 3-13	$S = (0.75)(3 \text{ ft}) = 2.25 \text{ ft} = 27 \text{ in}$ with $t = 6 \text{ in}$ \therefore class 50-150
19	Width classification	para 3-61 Table 3-4	<u>One lane:</u> W150 T150 <u>Two lanes:</u> W60 T60
20	Final classification	N/A	<u>One lane:</u> W43 T45 <u>Two lanes:</u> W35 T41

Table F-2. Classification Summary for a Timber-Stringer Bridge

Classification	W₁	W₂	T₁	T₂
Moment (step 10)	150	150	150	150
Shear (step 17)	43	35	45	41
Width (step 19)	150	60	150	60
Deck (step 18)	150	150	150	150
Final	43	35	45	41

NOTE: For one-lane bridges, the final classification is the smallest value of the moment, shear, and deck classifications. Post a width-restriction sign if the width classification is smaller than the final classification. For two-lane bridges, the final classification is the smallest value of the moment, shear, width, and deck classifications.

23. Sketches

a. SIDE ELEVATION SCALE 1 SQUARE = None

Looking North

Pile abutments

(Cross bracing on 15' spans omitted for clarity)

b. CROSS SECTION OF CRITICAL SPAN SCALE 1 SQUARE = None

2" X 4"

26'

24'

2" asphalt wearing surface

12" X 6" curbs

2" X 6" @ 100% deck

9 stringers

d. SITE PLAN SCALE 1 SQUARE = None

Heavner 10 mi

Kew Run (normally dry)

Forest Road 9013

Rob's Store

AB123456

US 210 (divided)

Jacksonville 15 mi

N

c. CROSS SECTION OF CRITICAL MEMBER SCALE 1 SQUARE = None

Piles 12"

Stringers 18" 8"

Caps 12"

24. Computation of Bridge Class

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Figure F-1. Sample Bridge-Reconnaissance Report for a Timber-Stringer Bridge

STEEL-STRINGER BRIDGE

F-3. In this example, *Table F-3* shows the procedure for classifying a steel-stringer bridge and *Table F-4* contains a classification summary. *Figure F-2*, page F-10, shows a sample bridge-reconnaissance report for a steel-stringer bridge. Information from an on-site inspection is as follows:

- The bridge is in excellent condition.
- The date built is unknown.
- The steel-stringer sections were identified by comparing dimensions with the section properties found in *Appendix D*.
- The concrete deck does not act to increase the moment capability of the stringers. Therefore, it is noncomposite.

Table F-3. Classification Procedure for a Steel-Stringer Bridge

Step	Equation/Procedure	Consideration	Computation
1	Yield stress Allowable stress	para 3-63 <i>Tables 3-5, 3-6</i>	$F_y = 30 \text{ ksi}$ $F_b = 0.75F_y = (0.75)(30) = 22.5 \text{ ksi}$
2	$m = \frac{F_b S}{I_2}$	para 3-64 (eq 3-2) Use <i>Table D-2</i> to find S.	Section = W36x300 $m = \frac{(22.5)(1,110)}{I_2} = 2,081.25 \text{ kip-feet}$
3	Total dead-load weight of the bridge components	para 3-29, 3-35 Compute for an average 1-ft length of bridge span. For W36x300, unit weight stringers = 300 lb/ft unit weight concrete = 150 lb/ft ³ unit weight braces = 42.7 lb/ft	$W'_{DL} = (5)(300) + \left[\left(7 \times \frac{1}{12} \right)(28) + (2)(1)(4.33) \right]$ $(150) + (20)(42.7) + 20 = 6,123 \text{ lb/ft}$ $W'_{DL} = \frac{6,123 \text{ lb/ft}}{1,000} = 6.12 \text{ kpf}$
4	$w_{DL} = \frac{W'_{DL}}{N_S}$	para 3-29 (eq 3-1)	$w_{DL} = \frac{W'_{DL}}{N_S} = \frac{6.12}{5} = 1.22 \text{ kpf}$
5	$m_{DL} = \frac{w_{DL} L^2}{8}$	para 3-35 (eq 3-3)	$m_{DL} = \frac{(1.22)(72^2)}{8} = 790.56 \text{ kip-feet}$
6	$m_{LL} = \frac{m - m_{DL}}{I + x}$	para 3-36 (eq 3-4) $x = 0.15 \text{ (steel)}$	$m_{LL} = \frac{2,081 - 790.56}{I + 0.15} = 1,122.12 \text{ kip-feet}$

Table F-3. Classification Procedure for a Steel-Stringer Bridge (continued)

Step	Equation/Procedure	Consideration	Computation
7	Number of effective members	para 3-32 <i>Table 3-3</i>	$S_s = 7 \text{ ft } 10 \text{ in} = 7.83 \text{ ft}$ and concrete deck on steel I-beams: <u>One lane:</u> $N_1 = \frac{14}{S_s} = \frac{14}{7.83} = 1.79$ <u>Two lanes:</u> $N_2 = \frac{11}{S_s} = \frac{11}{7.83} = 1.40$
8	$M_{LL} = N_{1,2}m_{LL}$	para 3-38 (eq 3-5)	<u>One lane:</u> $M_{LL} = (1.79)(1,122.12) = 2,008.59 \text{ kip-feet}$ <u>Two lanes:</u> $M_{LL} = (1.40)(1,122.12) = 1,570.97 \text{ kip-feet}$
9	Moment classification	Appendix B <i>Table B-2 or Figures B-1, B-2</i> $L = 72 \text{ ft}$	<u>One lane:</u> W65 T60 <u>Two lanes:</u> W50 T45
10	Deck classification	Seldom critical (para 3-65)	N/A
11	Width classification	<i>Table 3-4</i>	<u>One lane:</u> W150 T150 <u>Two lanes:</u> W100 T100
12	Final classification	para 3-66	<u>One lane:</u> W65 T60 <u>Two lanes:</u> W50 T45

Table F-4. Classification Summary for a Steel-Stringer Bridge

Classification	W ₁	W ₂	T ₁	T ₂
Moment (step 9)	65	50	60	45
Width (step 11)	150	100	150	100
Final	65	50	60	45
NOTE: For one-lane bridges, the final classification is the smallest value of the moment, shear, and deck classifications. Post a width-restriction sign if the width classification is smaller than the final classification. For two-lane bridges, the final classification is the smallest value of the moment, shear, width, and deck classifications.				

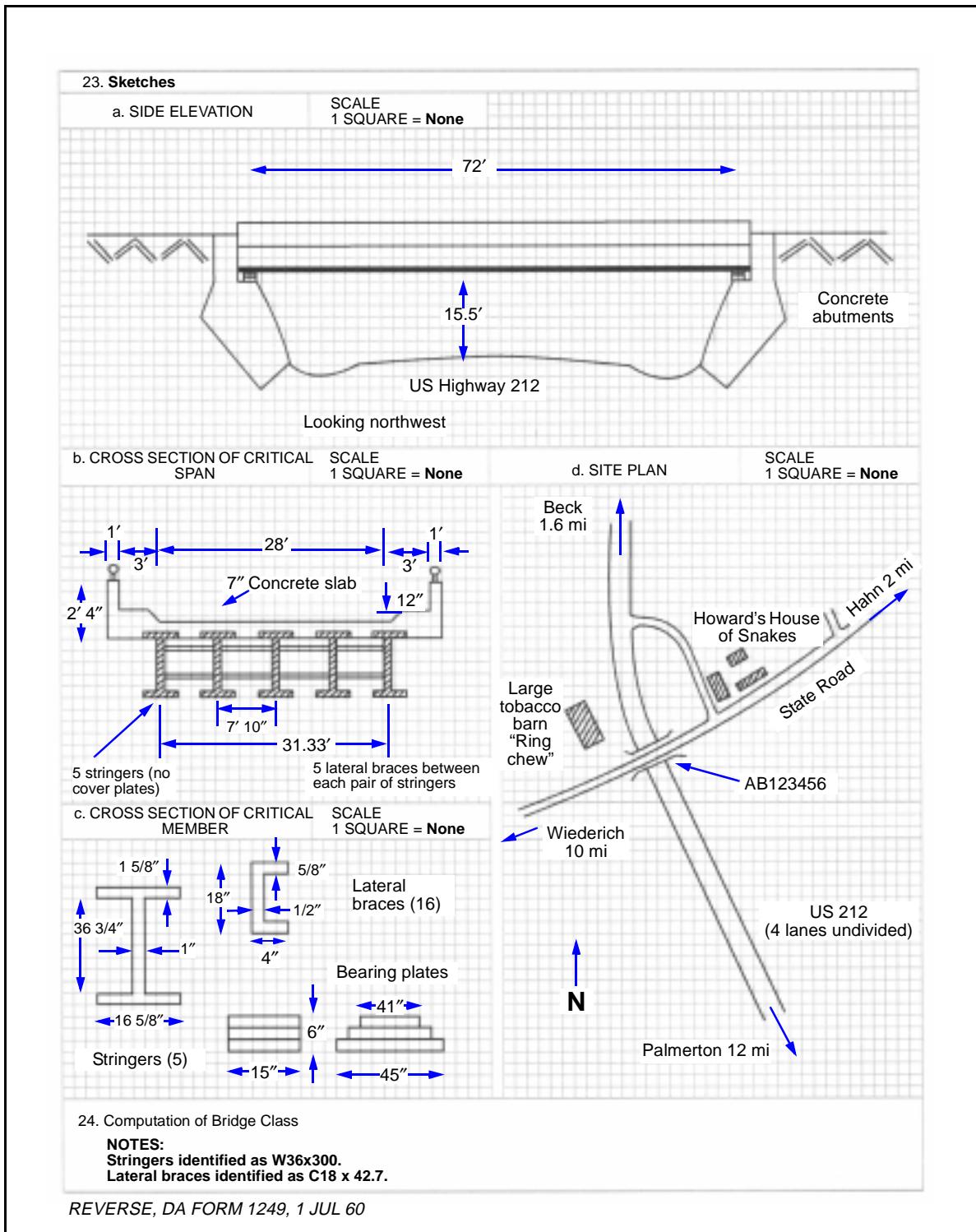


Figure F-2. Sample Bridge-Reconnaissance Report for a Steel-Stringer Bridge

COMPOSITE STEEL-CONCRETE STRINGER BRIDGE

F-4. In this example, *Table F-5*, pages F-11 through F-14, shows the procedure for classifying a composite steel-concrete stringer bridge and *Table F-6*, page F-14, contains a classification summary. *Figure F-3*, page F-15, shows a sample bridge-reconnaissance report, and *Figure F-4*, page F-16, shows a composite section of this bridge. Information from an on-site inspection is as follows:

- The bridge is in excellent condition.
- Full lateral support of the stringers is provided by the connection with the concrete deck.
- The steel-stringer sections were constructed from A36 steel (36 ksi yield), according to civilian authorities.
- The concrete allowable stress is 4,000 psi ($f'_c = 4,000 \text{ psi}$; and $r_m = 8$).
- $S_{\text{composite}}$ denotes the composite section modulus as determined according to paragraph 3-75.

Table F-5. Classification Procedure for a Composite Steel-Concrete Stringer Bridge

Step	Equation/Procedure	Consideration	Computation
1	Yield stress Allowable stress	para 3-63 A36 Steel <i>Table 3-6</i>	$F_y = 36 \text{ ksi}$ $F_b = 0.75F_y = (0.75)(36) = 27 \text{ ksi}$
2	Total dead-load weight of the bridge components	para 3-29, 3-35 Compute for an average 1-ft length of bridge span.	$W'_{DL} = \left[(8)\left(\frac{l}{12}\right) \right] (150)(28 \text{ ft}) + (2)(2.2)(150) + 40 + (4)\left[(47.25)\left(\frac{l}{144}\right) \right] (490) = 4,143.125 \text{ lb/ft}$ $W_{DL} = \frac{4,143.125 \text{ lb/ft}}{1,000} = 4.15 \text{ kpf}$
3	Number of effective members	para 3-32 <i>Table 3-3</i>	$S_s = 8.33 \text{ ft:}$ <u>One lane:</u> $N_1 = \frac{14}{S_s} = \frac{14}{8.33} = 1.68$ <u>Two lanes:</u> $N_2 = \frac{11}{S_s} = \frac{11}{8.33} = 1.32$
4	Equivalent span length	para 3-42	$L_{eff} = (0.7)(80) = 56 \text{ ft (for interior span)}$
5	$w_{DL} = \frac{W'_{DL}}{N_s}$	para 3-29 (eq 3-1)	$w_{DL} = \frac{W'_{DL}}{N_s} = \frac{4.15}{4} = 1.0375 \text{ kfp}$
6	$m_{DL} = \frac{w_{DL}L^2}{8}$	para 3-35 (eq 3-3) $L = L_{eff} = 56 \text{ ft}$	$m_{DL} = \frac{(1.0375)(56)^2}{8} = 406.7 \text{ kip-feet}$

Table F-5. Classification Procedure for a Composite Steel-Concrete Stringer Bridge (continued)

Step	Equation/Procedure	Consideration	Computation																									
			<table border="1"> <thead> <tr> <th>Section</th><th>A</th><th>\bar{y}</th><th>$A\bar{y}$</th></tr> </thead> <tbody> <tr> <td>Bottom flange</td><td>22.50</td><td>0.9375</td><td>21.09</td></tr> <tr> <td>Web</td><td>18.00</td><td>25.8800</td><td>465.84</td></tr> <tr> <td>Top flange</td><td>6.75</td><td>50.1600</td><td>338.58</td></tr> <tr> <td>$\Sigma =$</td><td>47.25</td><td>—</td><td>825.51</td></tr> </tbody> </table>	Section	A	\bar{y}	$A\bar{y}$	Bottom flange	22.50	0.9375	21.09	Web	18.00	25.8800	465.84	Top flange	6.75	50.1600	338.58	$\Sigma =$	47.25	—	825.51					
Section	A	\bar{y}	$A\bar{y}$																									
Bottom flange	22.50	0.9375	21.09																									
Web	18.00	25.8800	465.84																									
Top flange	6.75	50.1600	338.58																									
$\Sigma =$	47.25	—	825.51																									
7	<p>Section modulus:</p> $S_{steel} = \frac{I_s}{y_s}$ $y_c = \frac{\Sigma A \bar{y}}{\Sigma A}$ $I_s = \Sigma I_o + \Sigma A \bar{y}^2$ $I_o = \frac{bd^3}{12}$	<p>The values for \bar{y} are given.</p> <p>para 3-72</p>	$y_c = \frac{825.51}{47.25} = 17.47 \text{ in}$ $I_o \text{ top flange} = \frac{(12)(0.5625^3)}{12} = 0.1780$ $I_o \text{ web} = \frac{(0.375)(48^3)}{12} = 3,456$ $I_o \text{ bottom flange} = \frac{(12)(1.875^3)}{12} = 6.59$ <table border="1"> <thead> <tr> <th>Section</th><th>A</th><th>\bar{y}</th><th>$A\bar{y}^2$</th><th>I_o</th></tr> </thead> <tbody> <tr> <td>Bottom flange</td><td>22.50</td><td>16.53</td><td>6,147.92</td><td>6.5900</td></tr> <tr> <td>Web</td><td>18.0</td><td>8.41</td><td>1,273.11</td><td>3,456.0000</td></tr> <tr> <td>Top flange</td><td>6.75</td><td>32.69</td><td>7,231.29</td><td>0.1780</td></tr> <tr> <td>$\Sigma =$</td><td>—</td><td>—</td><td>14,652.32</td><td>3,462.7700</td></tr> </tbody> </table> $I_s = 3,462.77 + 14,652.32 = 18,115.09 \text{ in}^4$ $S_{steel} = \frac{18,115.09}{17.47} = 1,036.9 \text{ in}^3$	Section	A	\bar{y}	$A\bar{y}^2$	I_o	Bottom flange	22.50	16.53	6,147.92	6.5900	Web	18.0	8.41	1,273.11	3,456.0000	Top flange	6.75	32.69	7,231.29	0.1780	$\Sigma =$	—	—	14,652.32	3,462.7700
Section	A	\bar{y}	$A\bar{y}^2$	I_o																								
Bottom flange	22.50	16.53	6,147.92	6.5900																								
Web	18.0	8.41	1,273.11	3,456.0000																								
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$\Sigma =$	—	—	14,652.32	3,462.7700																								
8	Effective concrete-flange width	para 3-73	<p>Lesser value of:</p> $b'' = \frac{l}{4}(0.8)(80) \times 12 = 192 \text{ in}$ $b'' = (12)(7) = 84 \text{ in}$ $b'' = (8.33)(12) = 100 \text{ in}$ $\therefore b'' = 84 \text{ in}$																									
9	Equivalent steel-flange width	para 3-74 (eq 3-12) Table 3-7	$r_m = 8 \text{ (for } f'c = 4,000 \text{ psi)}$ $b' = \frac{84}{8} = 10.5 \text{ in}$																									

Table F-5. Classification Procedure for a Composite Steel-Concrete Stringer Bridge (continued)

Step	Equation/Procedure	Consideration	Computation			
			Section	A	\bar{y}	$A\bar{y}$
			Concrete	73.50	53.9400	3,964.59
			Top flange	6.75	50.1600	338.58
			Web	18.00	25.8800	465.84
			Bottom flange	22.50	0.9375	21.09
			$\Sigma =$	120.75	—	4,790.10
10	Section modulus of composite section: $S_{composite} = \frac{I_c}{y_c}$	The values for \bar{y} are given. para 3-75 Figure F-4	$I_o \text{ concrete} = \frac{(10.5)(7^3)}{12} = 300.13$			
	$y_c = \frac{\sum A \bar{y}}{\sum A}$		$I_o \text{ top flange} = \frac{(12)(0.5625^3)}{12} = 0.1780$			
	$I_c = \sum I_o + \sum A \bar{y}^2$		$I_o \text{ web} = \frac{(0.375)(48^3)}{12} = 3,456$			
	$I_o = \frac{bd^3}{12}$		$I_o \text{ bottom flange} = \frac{(12)(1.875^3)}{12} = 6.59$			
			Section	A	\bar{y}	$A\bar{y}^2$
			Concrete	73.50	14.27	14,967.02
			Top flange	6.75	10.49	742.77
			Web	18.00	13.79	3,422.95
			Bottom flange	22.50	38.73	33,750.29
			$\Sigma =$	—	—	52,883.03
11	$F_{DL} = \frac{m_{DL}l^2}{S_{steel}}$	para 3-76 (eq 3-13)	$I_c = 3,762.9 + 52,883.03 = 56,645.93 \text{ in}^4$			
			$S_{composite} = \frac{56,645.93}{39.67} = 1,427.93 \text{ in}^3$			
12	$m_{LL} = \frac{(F_b - F_{DL})S_{composite}}{(1+x)l^2}$	para 3-77 (eq 3-14) $x = 0.15 \text{ (steel)}$	$F_{DL} = \frac{(406.7)(12)}{1,036.9} = 4.71 \text{ ksi}$			
			$m_{LL} = \frac{(27 - 4.71)(1,427.93)}{(1 + 0.15)(12)} = 2,306.42 \text{ kip-feet}$			

Table F-5. Classification Procedure for a Composite Steel-Concrete Stringer Bridge (continued)

Step	Equation/Procedure	Consideration	Computation	
13	$M_{LL} = N_{I,2} m_{LL}$	para 3-38 (eq 3-5)	<u>One lane:</u> $M_{LL} = (1.68)(2,306.29) = 3,874.57 \text{ kip-feet}$ <u>Two lanes:</u> $M_{LL} = (1.32)(2,306.29) = 3,044.30 \text{ kip-feet}$	
14	Moment classification	Appendix B Table B-2 or Figures B-1, B-2 $L = L_{eff} = 56 \text{ ft}$	<u>One lane:</u> W150 T150	<u>Two lanes:</u> W150 T150
15	Width classification	Table 3-4	<u>One lane:</u> W150 T150	<u>Two lanes:</u> W100 T100
16	Final classification	para 3-79	<u>One lane:</u> W150 T150	<u>Two lanes:</u> W100 T100

Table F-6. Classification Summary for a Composite Steel-Concrete Stringer Bridge

Classification	W ₁	W ₂	T ₁	T ₂
Moment (step 14)	150	150	150	150
Width (step 15)	150	100	150	100
Final	150	100	150	100
NOTE: For one-lane bridges, the final classification is the smallest value of the moment, shear, and deck classifications. Post a width-restriction sign if the width classification is smaller than the final classification. For two-lane bridges, the final classification is the smallest value of the moment, shear, width, and deck classifications.				

23. Sketches

a. SIDE ELEVATION	SCALE 1 SQUARE = None		
<p>Concrete abutments East-bound lanes West-bound lanes</p> <p>Interstate</p>			
b. CROSS SECTION OF CRITICAL SPAN	SCALE 1 SQUARE = None	d. SITE PLAN	SCALE 1 SQUARE = None
<p>28' 2'8" 10"</p> <p>8'4" 2'</p> <p>25' 4'2"</p>		<p>Nagel and Son Hardware Store</p> <p>Fowler Drive</p> <p>AB123456</p> <p>Vines 3 mi</p> <p>Cowgill 26 mi</p> <p>Interstate 100 (4 lanes divided)</p> <p>County Road 12</p> <p>Mullen Street</p> <p>Lafourche County Sewage Treatment Facility</p> <p>N</p>	
c. CROSS SECTION OF CRITICAL MEMBER	SCALE 1 SQUARE = None		
<p>(No wearing surface)</p> <p>7" 1 1/2"</p> <p>50"</p> <p>3/8"</p> <p>1 7/8"</p> <p>12"</p> <p>Top flange embedded in concrete</p>			

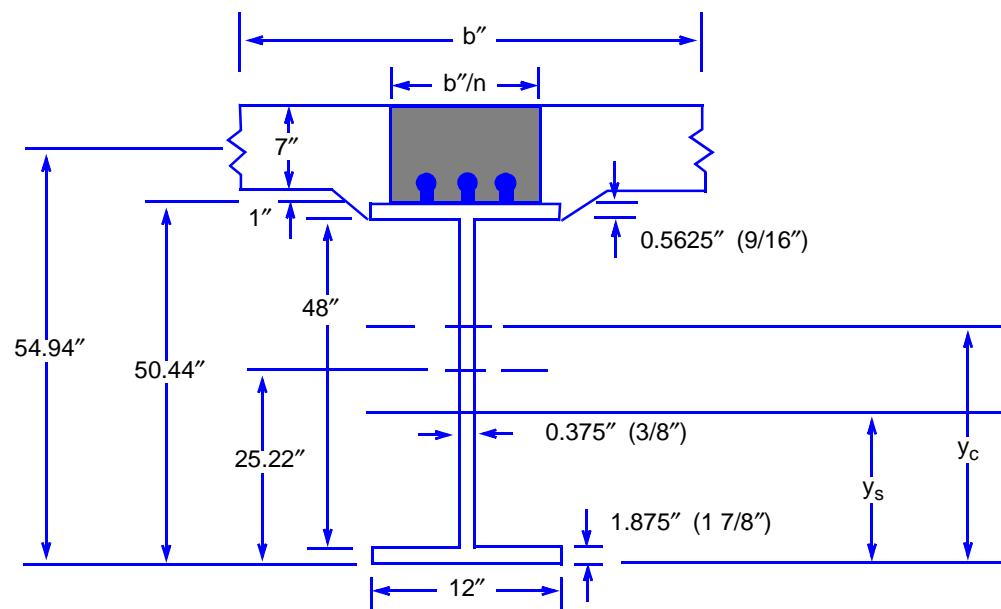
24. Computation of Bridge Class

NOTES:
Bearing plates: 12" x 16" x 2".
No cover plates on stringer.

Details of stringer from as-built plans on attached sheet.

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Figure F-3. Sample Bridge-Reconnaissance Report for a Composite Steel-Concrete Stringer Bridge



LEGEND:

n = modular ratio between concrete and steel

y_c = centroid of the composite section

y_s = centroid of the steel section alone

Figure F-4. Composite Section

STEEL-GIRDER BRIDGE

F-5. In this example, *Table F-7*, pages F-17 through F-20, shows the procedure for classifying a steel-girder bridge, and *Table F-8*, page F-21, contains a classification summary for a steel-girder bridge. *Figure F-5*, page F-22, shows a sample bridge-reconnaissance report for a steel-girder bridge. *Figures F-6 and F-7*, page F-23, show details of the girder. According to civilian authorities, the deck is a concrete slab constructed of noncomposite construction.

Table F-7. Classification Procedure for a Steel-Girder Bridge

Step	Equation/Procedure	Consideration	Computation
1	Yield stress Allowable stress	para 3-63 <i>Tables 3-5, 3-6</i>	$F_y = 30 \text{ ksi } (\text{unknown type and date})$ $F_b = 0.75F_y = (0.75)(30) = 22.5 \text{ ksi}$
2	Effective number of girders: <u>One lane:</u> $N_1 = \frac{2S_g}{S_g + b_r - 10}$ <u>Two lanes:</u> $C_v = b_r - 2S_e - 3 \geq 2.0 \text{ ft}$ $N_2 = \frac{S_g}{S_g + b_r - 17 - C_v}$	para 3-83 (eq 3-15, 3-16) para 3-84 (eq 3-17)	<u>One lane:</u> $N_1 = \frac{(2)(30)}{30 + 24 - 10} = 1.36$ <u>Two lanes:</u> $C_v = 24 - (2)(7) - 3 = 7$ $N_2 = \frac{30}{30 + 24 - 17 - 7} = 1.0$
3	$S_{girder} = d_w \left(A_{f(1)} + \frac{A_w}{6} \right) + d_i A_{fa}$	Deduct cross-sectional area of rivet holes. Use approximate section modulus equation. (eq D-7)	$A_{f(1)} = (15)(3) + (2)(6 \times 0.75) + (2)(1)(3.75)$ $= 61.5 \text{ in}^2$ $A_w = (60)(1) - (10)(1)(1) = 50 \text{ in}^2$ $A_{fa} = (2)(7.25)(0.75) - (2)(1)(2.5) = 5.88 \text{ in}^2$ $S_{girder} = 61 \left(46.5 + \frac{50}{6} \right) + (45)(5.88) = 3,609.41 \text{ in}^3$
4	$m = \frac{F_b S}{I_2}$	para 3-86 (eq 3-18)	$m = \frac{(22.5)(3,609.41)}{I_2} = 6,767.64 \text{ kip-feet}$
5	Area girder	para 3-87	$A_{flanges} = (6)(15)(1) = 90 \text{ in}^2$ $A_{angles} = (4)(9.94) = 39.76 \text{ in}^2$ $A_{web} = (60)(1) = 60 \text{ in}^2$ $A_{girder} = (90 + 39.76 + 60) = 189.7 \text{ in}^2$

Table F-7. Classification Procedure for a Steel-Girder Bridge (continued)

Step	Equation/Procedure	Consideration	Computation
6	Dead load per girder	para 3-87 (eq 3-19 through 3-22)	$w_{FS} = \left[(7)(26)(150) + \left(\frac{(490)(24.7)(7)}{12} \right) + \left(\frac{(490)(88.3)(30)}{(12)(33.3)} \right) \right] \times \frac{(33.3)(4 - I)}{(12,000)(2)(100)} = 1.56 \text{ kpf}$ $w_g = \frac{(490)(189.76)}{144,000} = 0.646 \text{ kpf}$ $w_b = \frac{(490)(6.09)(3.96)(72)}{(2)(100)(144,000)} = 0.0295 \text{ kpf}$ $w_{DL} = 1.565 + 0.646 + 0.0295 = 2.241 \text{ kpf}$
7	$m_{DL} = \frac{w_{DL}L^2}{8}$	para 3-88 (eq 3-23)	$m_{DL} = \frac{(2.241)(100^2)}{8} = 2,801.25 \text{ kip-feet}$
8	$m_{LL} = \frac{m - m_{DL}}{I + x}$	para 3-89 (eq 3-24)	$m_{LL} = \frac{6,767.64 - 2,801.25}{I + 0.15} = 3,449.03 \text{ kip-feet}$
9	$M_{LL} = N_{I,2}m_{LL}$	para 3-90 (eq 3-25)	<u>One lane:</u> $M_{LL} = (1.36)(3,449.03) = 4,690.68 \text{ kip-feet}$ <u>Two lanes:</u> $M_{LL} = (1.0)(3,449.03) = 3,449.03 \text{ kip-feet}$
10	Girder moment classification	Appendix C para 3-91 <i>Table B-2 or Figures B-1, B-2</i> $L = 100 \text{ ft}$	<u>One lane:</u> W100 T100 <u>Two lanes:</u> W75 T75
11	Dead load per stringer	para 3-29, 3-35	$w_{DL} = \left[(7)(4)(150) + \frac{(490)(24.7)}{12} \right] \times \frac{I}{12,000}$ $= 0.434 \text{ kpf}$
12	Effective number of stringers	para 3-32, 3-92 <i>Table 3-3</i>	$S_s = 4 \text{ ft:}$ <u>One lane:</u> $N_1 = \frac{14}{S_s} = \frac{14}{4} = 3.5$ <u>Two lanes:</u> $N_2 = \frac{11}{S_s} = \frac{11}{4} = 2.75$
13	$m = \frac{F_b S}{I2}$	para 3-64 (eq 3-2) Use <i>Table D-2</i> to find S.	$m = \frac{(22.5)(196)}{12} = 367.5 \text{ kip-feet}$
14	$m_{DL} = \frac{w_{DL}L^2}{8}$	para 3-29, 3-35 (eq 3-3, 3-26) $L = S_f = 33.3 \text{ ft}$	$m_{DL} = \frac{(0.434 \text{ kpf})(33.3 \text{ ft}^2)}{8} = 60.16 \text{ kip-feet}$

Table F-7. Classification Procedure for a Steel-Girder Bridge (continued)

Step	Equation/Procedure	Consideration	Computation
15	$m_{LL} = \frac{m - m_{DL}}{I + x}$	para 3-36 (eq 3-4) $x = 0.15$ (steel)	$m_{LL} = \frac{367.5 - 60.16}{I + 0.15} = 267.25 \text{ kip-feet}$
16	$M_{LL} = N_{1,2}m_{LL}$	para 3-38 (eq 3-5)	<u>One lane:</u> $M_{LL} = (3.5)(267.25) = 935.38 \text{ kip-feet}$ <u>Two lanes:</u> $M_{LL} = (2.75)(267.25) = 734.94 \text{ kip-feet}$
17	Stringer moment classification	Appendix B Table B-2 or Figures B-1, B-2 $L = 33.3 \text{ ft}$	<u>One lane:</u> W100 <u>Two lanes:</u> W80 T75 T55
18	Allowable shear stress	para 3-63, 3-93 Table 3-6	$F_v = 0.45F_y = (0.45)(30) = 13.5 \text{ ksi}$
19	$v = A_v F_v$	para 3-93 (eq 3-27) Obtain A_v from Table D-2.	$v = (10.60 \text{ in}^2)(13.5 \text{ ksi}) = 143.1 \text{ kips}$
20	$v_{DL} = \frac{w_{DL}S_f}{2}$	para 3-93 (eq 3-28)	$v_{DL} = \frac{(0.434)(33.3)}{2} = 7.23 \text{ kips}$
21	$v_{LL} = v - v_{DL}$	para 3-93 (eq 3-29)	$v_{LL} = 143.1 - 7.23 = 135.87 \text{ kips}$
22	$V_{LL} = \frac{2v_{LL}}{1.15}$	para 3-93 (eq 3-30)	$V_{LL} = \frac{(2)(135.85)}{1.15} = 236.26 \text{ kips}$
23	Stringer shear classification	Appendix B Table B-3 or Figures B-3, B-4 $L = 33.3 \text{ ft}$	<u>One lane:</u> W150 <u>Two lanes:</u> W150 T150 T150
24	$m = \frac{F_b S}{I_2}$ for floor beams	para 3-95 (eq 3-31) Use Table D-2 to find S.	$m = \frac{(22.5)(1,110)}{I_2} = 2,081.25 \text{ kip-feet}$
25	Dead load per floor beam	para 3-96 (eq 3-32)	$w_{DL} = \left[(7)(26)(150) + \left(\frac{(490)(24.7)(7)}{I_2} \right) + \left(\frac{(490)(88.3)(30)}{(12)(33.3)} \right) \right] \times \frac{33.3}{(12,000)(100)} = 1.04 \text{ kpf}$
26	$m_{DL} = \frac{w_{DL}S_g^2}{8}$	para 3-96 (eq 3-33)	$m_{DL} = \frac{(1.04)(30^2)}{8} = 117.0 \text{ kip-feet}$
27	$m_{LL} = \frac{m - m_{DL}}{I + x}$	para 3-97 (eq 3-34) $x = 0.15$ (steel)	$m_{LL} = \frac{2,081.25 - 117.0}{I + 0.15} = 1,708.04 \text{ kip-feet}$
28	One-way traffic: $P_e = 2m_{LL}\left(\frac{1}{S_g - S_e}\right)$	para 3-98 (eq 3-35) $S_e = 7 \text{ ft}$	$P_e = (2)(1,708.04)\left(\frac{1}{30 - 7}\right) = 148.53 \text{ kips}$

Table F-7. Classification Procedure for a Steel-Girder Bridge (continued)

Step	Equation/Procedure	Consideration	Computation
29	Two-way traffic: $P_e = m_{LL} \left(\frac{I}{S_g - S_e - C_v} \right)$	para 3-98 (eq 3-36) Use C_v as computed in step 2.	$P_e = (1,708.04) \left(\frac{I}{30 - 7 - 7} \right) = 106.75 \text{ kips}$
30	Floor-beam moment classification	para 3-99 <i>Figures 3-21 through 3-24</i> $L = 33.3 \text{ ft}$	<u>One lane:</u> W150 T150 <u>Two lanes:</u> W150 T150
31	$v = A_v F_v$	para 3-101 (eq 3-37) Obtain A_v from <i>Table D-2</i> .	$v = (31.5)(13.5) = 425.25 \text{ kips}$
32	$v_{DL} = \frac{w_{DL} S_g}{2}$	para 3-102 (eq 3-38)	$v_{DL} = \frac{(1.04)(30)}{2} = 15.6 \text{ kips}$
33	$v_{LL} = \frac{v - v_{DL}}{1 + x}$	para 3-103 (eq 3-39) $x = 0.15$ (steel)	$v_{LL} = \frac{(425.25 - 15.6)}{1 + 0.15} = 356.22 \text{ kips}$
34	One-way traffic: $P_e = v_{LL} S_g \left(\frac{I}{S_g + b_r - 3.0 - S_e} \right) \geq v_{LL}$	para 3-104 (eq 3-40)	$P_e = (356.22)(30) \left(\frac{I}{30 + 24 - 3 - 7} \right)$ $= 242.88 \text{ kips} < 425.25 \text{ kips}$ $\therefore P_e = 425.25 \text{ kips}$
35	Two-way traffic: $P_e = \frac{v_{LL} S_g}{2}$ $\left(\frac{I}{S_g + b_r - 3.0 - 2S_e - C_v} \right) \geq 2v_{LL}$	para 3-104 (eq 3-41)	$P_e = \frac{(356.22)(30)}{2} \left(\frac{I}{30 + 24 - 3 - 27 - 7} \right)$ $= 314.31 \text{ kips} < 850.5 \text{ kips}$ $\therefore P_e = 850.5 \text{ kips}$
36	Floor-beam shear classification	para 3-106 <i>Figures 3-21 through 3-24</i>	<u>One lane:</u> W150 T150 <u>Two lanes:</u> W150 T150
37	Deck classification	para 3-107 Not critical here.	N/A
38	Width classification	<i>Table 3-4</i>	<u>One lane:</u> W150 T150 <u>Two lanes:</u> W60 T60
39	Final classification	N/A	<u>One lane:</u> W100 T75 <u>Two lanes:</u> W60 T55

Table F-8. Classification Summary for a Steel-Girder Bridge

Classification	W₁	W₂	T₁	T₂
Girder (step 10)	100	75	100	75
Moment (stringer) (step 17)	100	80	75	55
Shear (stringer) (step 23)	150	150	150	150
Floor beam (moment) (step 30)	150	150	150	150
Floor beam (shear) (step 36)	150	150	150	150
Deck (step 37)	N/A	N/A	N/A	N/A
Width (step 38)	150	60	150	60
Final	100	60	75	55

NOTE: For one-lane bridges, the final classification is the smallest value of the moment, shear, and deck classifications. Post a width-restriction sign if the width classification is smaller than the final classification. For two-lane bridges, the final classification is the smallest value of the moment, shear, width, and deck classifications.

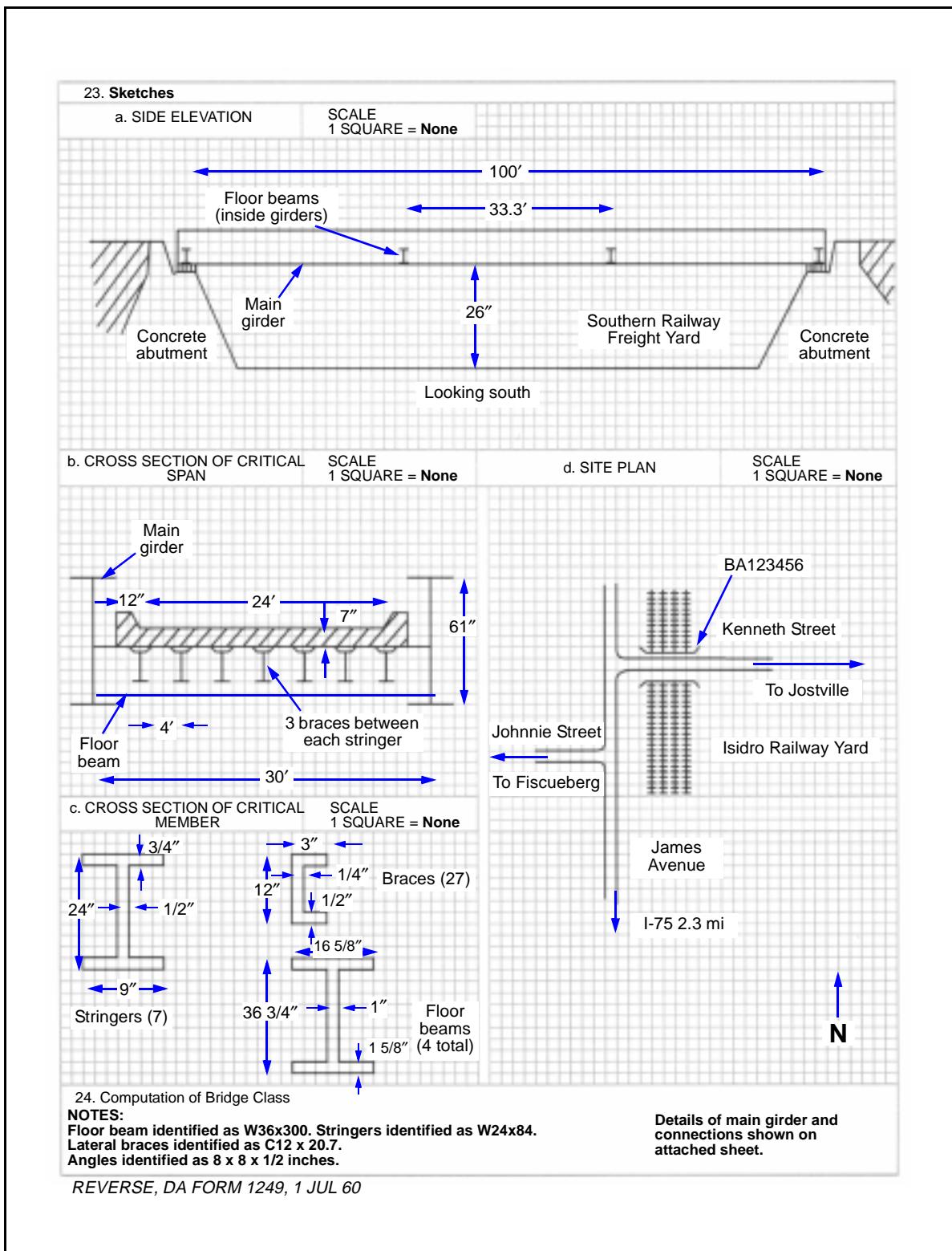


Figure F-5. Sample Bridge-Reconnaissance Report for a Steel-Girder Bridge

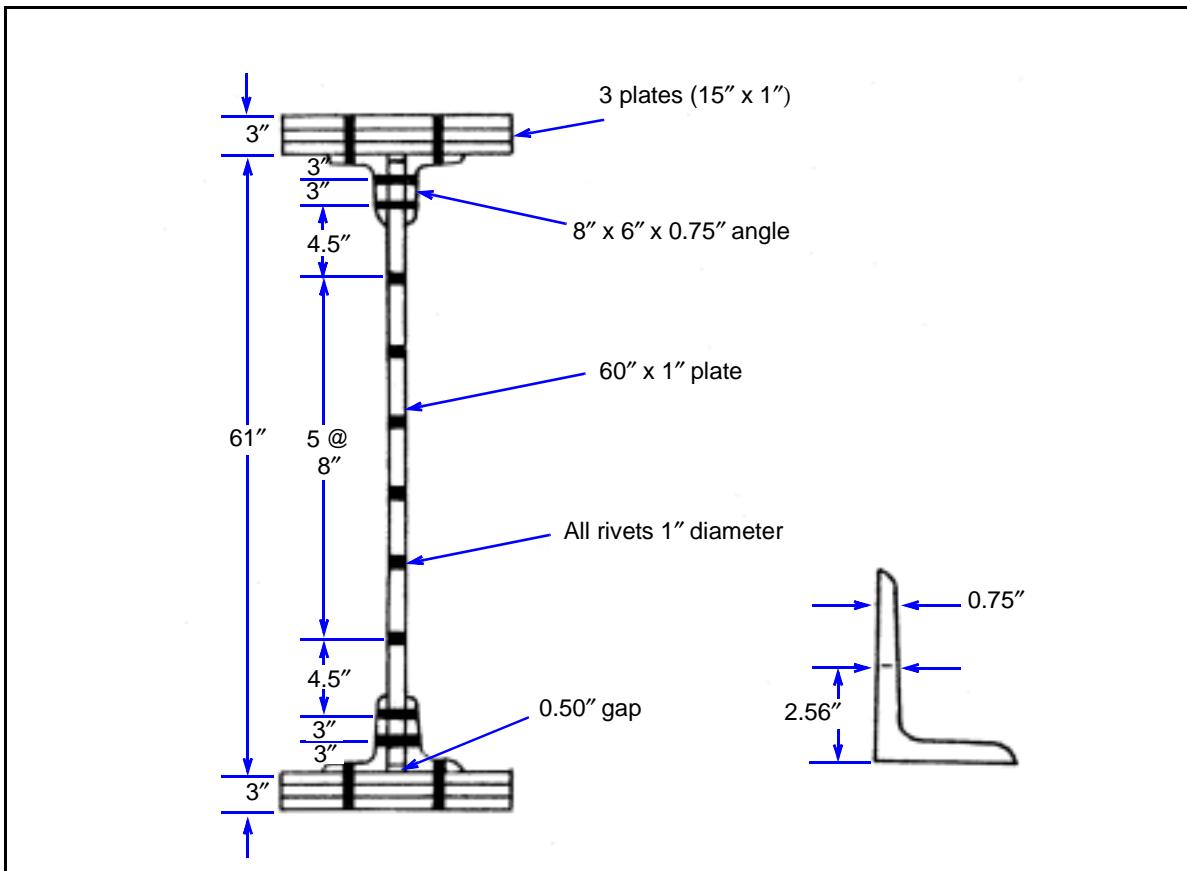


Figure F-6. Detail of the Main Girder

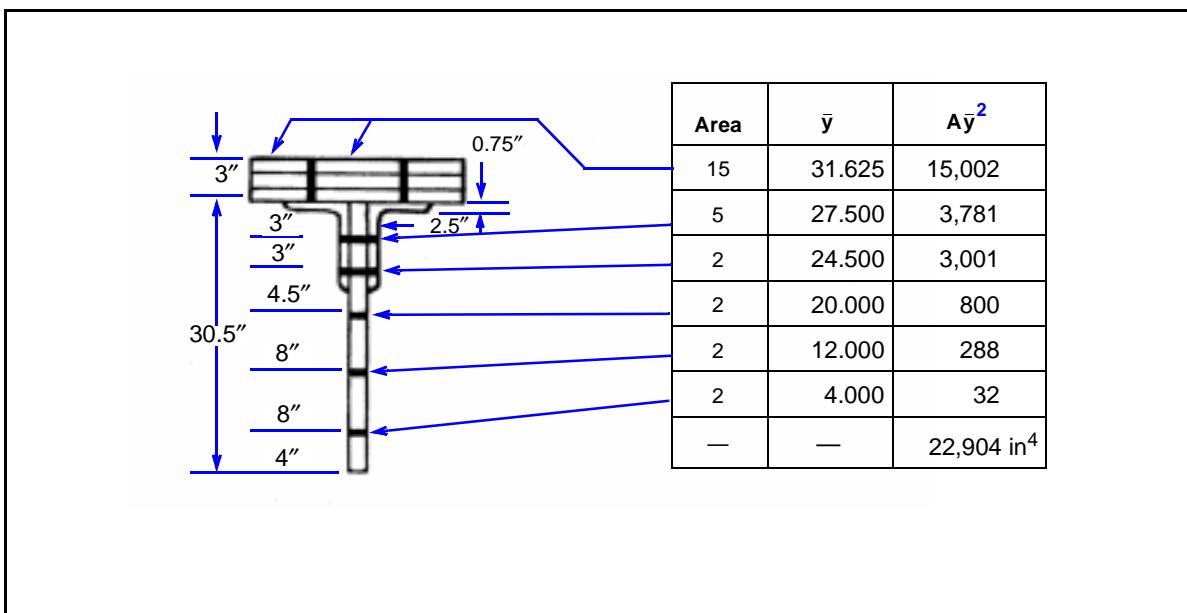


Figure F-7. Moment of Inertia of the Rivet Holes

TRUSS BRIDGE

F-6. In this example, *Table F-9, pages F-24 through F-28*, shows the procedure for classifying a truss bridge. *Table F-10, page F-28*, contains a classification summary. *Figure F-8, page F-29*, shows a sample bridge-reconnaissance report for a truss bridge. *Figures F-9 and F-10, page F-30*, show details of the bridge.

Table F-9. Classification Procedure for a Truss Bridge

Step	Equation/Procedure	Consideration	Computation
1	Area tension cord: $A_{angles} = 4(2.11) = 8.44 \text{ in}^2$ $A_{plates} = 2(18)(1) = 36 \text{ in}^2$ $A_{rivets} = \frac{\pi(0.75)^2}{4} \times 4 = 1.77 \text{ in}^2$	N/A	$A_t = A_{angles} + A_{plates} + A_{rivets}$ $= 8.44 + 36 + 1.77 = 46.21 \text{ in}^2$
2	Through-deck truss	para 3-116 (eq 3-45)	$W_{DL} = \frac{[190(38) + 25(46.21) + 260(6) + 120(7) - 2,400]}{1,000}$ $= 8.375 \text{ kpf}$
3	$w_{DL} = \frac{W_{DL}}{N_t}$	para 3-117 (eq 3-46)	$w_{DL} = \frac{8.375}{2} = 4.19 \text{ kpf}$
4	$m_{DL} = \frac{w_{DL}L^2}{8}$	para 3-118 (eq 3-47)	$m_{DL} = \frac{(4.19)(160^2)}{8} = 13,408 \text{ kip-feet}$
5	Yield stress Allowable tensile stress	para 3-63 Tables 3-5, 3-6	$F_y = 30 \text{ ksi (unknown type and data)}$ $F_t = 0.75F_y = 0.75(30) = 22.5 \text{ ksi}$
6	Net-area tension chord	Deduct cross-sectional area of rivet holes.	$A_{angles_{net}} = 8.44 - (4)(0.375)(0.75) = 7.32 \text{ in}^2$ $A_{plates_{net}} = 36 - (4)(1)(0.75) = 33 \text{ in}^2$ $A_n = 7.32 + 33 = 40.32 \text{ in}^2$
7	$T = F_t A_n$	para 3-119 (eq 3-48)	$T = (22.5)(40.32) = 907.2 \text{ kips}$
8	$\frac{KL_x}{r_x}$ and— $\frac{KL_y}{r_y}$	para 3-120 (eq 3-49, 3-50) Use $K = 0.88$ (for unknown type). Determine r_x and r_y from para D-15 and eq D-8.	$L_x = L_y = 20 \text{ ft}$ $\frac{KL_x}{r_x} = \frac{(0.88)(20)(12)}{(0.39)(18)} = 30.09$ $\frac{KL_y}{r_y} = \frac{(0.88)(20)(12)}{(0.55)(12.5)} = 30.72$

Table F-9. Classification Procedure for a Truss Bridge (continued)

Step	Equation/Procedure	Consideration	Computation
9	Allowable compressive stress	para 3-121 Table 3-9 $C_c = 138.1$ (for unknown type and date). Use $\frac{KL}{r} = \frac{KL_y}{r_y}$ $= 30.72$	$\frac{KL}{r} = 30.72 \leq C_c$ $F_c = 17,650 - (0.46)(30.72^2) = 17,215.89 \text{ psi}$ $F_c = \frac{17,215.89}{1,000} = 17.22 \text{ ksi}$
10	Area compression cord: $A_{angles} = 2(2.48) + 2(4.0) = 12.96 \text{ in}^2$ $A_{plates} = 2(18)(0.75) + 1(21)(0.438)$ $= 36.2 \text{ in}^2$ $A_{rivets} = \frac{\pi(0.75)^2}{4} \times 4 = 2.65 \text{ in}^2$	N/A	$A_g = A_{angles} + A_{plates} + A_{rivets}$ $= 12.96 + 36.2 + 2.65 = 51.81 \text{ in}^2$
11	$C = F_c A_g$	para 3-121 (eq 3-51)	$C = (17.22)(51.81) = 892.17 \text{ kips}$
12	$m = F'd'$	para 3-122 (eq 3-52) $F' = C$ $= 892.17 \text{ kips}$	$m = (892.17)(24) = 21,412.08 \text{ kip-feet}$
13	$m_{LL} = \frac{m - m_{DL}}{1.15}$	para 3-123 (eq 3-53)	$m_{LL} = \frac{21,412.08 - 13,408}{1.15} = 6,960.07 \text{ kip-feet}$
14	Effective numbers of trusses: <u>One lane:</u> $N_1 = \frac{2S_t}{S_t + b_r - 10}$ <u>Two lanes:</u> $C_v = b_r - 2S_e - 3.0 \geq 2.0 \text{ ft}$ $N_2 = \frac{S_t}{S_t + b_r - 17 - C_v}$	para 3-124 (eq 3-54, 3-55, 3-56)	<u>One lane:</u> $N_1 = \frac{(2)(43)}{43 + 38 - 10} = 1.21$ <u>Two lanes:</u> $C_v = 38 - (2)(7) - 3 = 21$ $N_2 = \frac{43}{43 + 38 - 17 - 21} = 1.0$
15	$M_{LL} = N_{I,2}m_{LL}$	para 3-125 (eq 3-57)	<u>One lane:</u> $M_{LL} = (1.21)(6,960.07) = 8,421.68 \text{ kip-feet}$ <u>Two lanes:</u> $M_{LL} = (1.0)(6,960.07) = 6960.07 \text{ kip-feet}$
16	Truss moment classification	para 3-126 Appendix B Table B-2 or Figures B-1, B-2 $L = 160 \text{ ft}$	<u>One lane:</u> W100 W110 <u>Two lanes:</u> W85 T90
17	Stringer: Yield stress Allowable stress	para 3-63, 3-127 Tables 3-5, 3-6	$F_y = 30 \text{ ksi}$ (unknown type and date) $F_b = 0.75F_y = (0.75)(30) = 22.5 \text{ ksi}$

Table F-9. Classification Procedure for a Truss Bridge (continued)

Step	Equation/Procedure	Consideration	Computation
18	Dead load per stringer	para 3-29, 3-35 Interior stringers control.	$w_{DL} = \left[(6)(6.33)(150) + \frac{(490)(27.7)}{12} \right] \times \frac{1}{12,000}$ $= 0.569 \text{ kpf}$
19	Effective number of stringers	para 3-32, 3-92 <i>Table 3-3</i>	$S = 6.33 \text{ ft:}$ <u>One lane:</u> $N_1 = \frac{14}{S} = 2.21$ <u>Two lanes:</u> $N_2 = \frac{11}{S} = 1.74$
20	$m = \frac{F_b S}{12}$	para 3-64 (eq 3-2) Use <i>Table D-2</i> to find S (W24x94).	$m = \frac{(22.5)(222)}{12} = 416.25 \text{ kip-feet}$
21	$m_{DL} = \frac{w_{DL} L^2}{8}$	para 3-29, 3-35 (eq 3-3, 3-26) $L = S_f = 20 \text{ ft}$	$m_{DL} = \frac{(0.569)(20)^2}{8} = 28.45 \text{ kip-feet}$
22	$m_{LL} = \frac{m - m_{DL}}{I + x}$	para 3-36 (eq 3-4) $x = 0.15 \text{ (steel)}$	$m_{LL} = \frac{416.25 - 28.45}{I + 0.15} = 337.25 \text{ kip-feet}$
23	$M_{LL} = N_{1,2} m_{LL}$	para 3-38 (eq 3-5)	<u>One lane:</u> $M_{LL} = (2.21)(337.22) = 745.25 \text{ kip-feet}$ <u>Two lanes:</u> $M_{LL} = (1.74)(337.22) = 586.76 \text{ kip-feet}$
24	Stringer moment classification	<i>Appendix B</i> <i>Table B-2 or</i> <i>Figures B-1, B-2</i> $L = 20 \text{ ft}$	<u>One lane:</u> W150 <u>Two lanes:</u> W150 T150 T110
25	Allowable shear stress	para 3-63, 3-93 <i>Table 3-6</i>	$F_v = 0.45 F_y = (0.45)(30) = 13.5 \text{ ksi}$
26	$v = A_v F_v$	para 3-93 (eq 3-27) Obtain A_v from <i>Table D-2</i> .	$v = (11.64)(13.5) = 157.14 \text{ kips}$
27	$v_{DL} = \frac{w_{DL} S_f}{2}$	para 3-93 (eq 3-28)	$v_{DL} = \frac{(0.569)(20)}{2} = 5.69 \text{ kips}$
28	$v_{LL} = v - v_{DL}$	para 3-93 (eq 3-29)	$v_{LL} = 157.14 - 5.69 = 151.45 \text{ kips}$
29	$V_{LL} = \frac{2v_{LL}}{1.15}$	para 3-93 (eq 3-30)	$V_{LL} = \frac{(2)(151.45)}{1.15} = 263.39 \text{ kips}$
30	Stringer shear classification	<i>Appendix B</i> <i>Table B-3 or</i> <i>Figures B-3, B-4</i> $L = 20 \text{ ft}$	<u>One lane:</u> W150 <u>Two lanes:</u> W150 T150

Table F-9. Classification Procedure for a Truss Bridge (continued)

Step	Equation/Procedure	Consideration	Computation
31	For floor beams: $m = \frac{F_b S}{I_2}$	para 3-95 (eq 3-31) Use Table D-2 to find S (W36x280).	$m = \frac{(22.5)(1,030)}{12} = 1,931.25 \text{ kip-feet}$
32	Dead load per floor beam	para 3-96 (eq 3-32)	$w_{DL} = \left[(6)(40)(150) + \frac{(490)(27.7)(7)}{12} + \frac{(490)(82.4)(43)}{(12)(20)} \right] \times \frac{20}{(12,000)(160)} = 0.533 \text{ kpf}$
33	$m_{DL} = \frac{w_{DL} S_f^2}{8}$	para 3-96 (eq 3-33)	$m_{DL} = \frac{(0.533)(30^2)}{8} = 59.96 \text{ kip-feet}$
34	$m_{LL} = \frac{m - m_{DL}}{I + x}$	para 3-97 (eq 3-34) $x = 0.15$ (steel)	$m_{LL} = \frac{(1,931.25 - 59.96)}{1 + 0.15} = 1,627.21 \text{ kip-feet}$
35	One-way traffic: $P_e = 2m_{LL}\left(\frac{1}{S_g - S_e}\right)$	para 3-98 (eq 3-35)	$P_e = (2)(1,627.21)\left(\frac{1}{43 - 7}\right) = 90.40 \text{ kips}$
36	Two-way traffic: $P_e = 2m_{LL}\left(\frac{1}{S_g - S_e - C_v}\right)$	para 3-98 (eq 3-36) Use C_v as computed in step 14.	$P_e = (2)(1,627.23)\left(\frac{1}{43 - 7 - 21}\right) = 216.96 \text{ kips}$
37	Floor-beam moment classification	para 3-99 Figures 3-21 through 3-24 $L = 20 \text{ ft}$	<u>One lane:</u> W150 T150 <u>Two lanes:</u> W150 T150
38	$v = A_v F_v$	para 3-101 (eq 3-37) Obtain A_v from Table D-2.	$v = (29.6 \text{ in}^2)(13.5 \text{ ksi}) = 399.6 \text{ kips}$
39	$v_{DL} = \frac{w_{DL} S_g}{2}$	para 3-102 (eq 3-38)	$v_{DL} = \frac{(0.533)(43)}{2} = 11.46 \text{ kips}$
40	$v_{LL} = \frac{v - v_{DL}}{I + x}$	para 3-103 (eq 3-39) $x = 0.15$ (steel)	$v_{LL} = \frac{399.6 - 11.46}{1 + 0.15} = 337.51 \text{ kips}$
41	One-way traffic: $P_e = v_{LL} S_g \left(\frac{1}{S_g + b_r - 3.0 - S_e} \right) \geq v_{LL}$	para 3-104 (eq 3-40)	$P_e = (337.51)(43) \left(\frac{1}{43 + 38 - 3 - 7} \right)$ $= 204.41 \text{ kips} < 399.6 \text{ kips}$ $\therefore P_e = 399.6 \text{ kips}$
42	Two-way traffic: $P_e = \frac{v_{LL} S_g}{2} \left(\frac{1}{S_g + b_r - 3.0 - 2S_e - C_v} \right) \geq 2v_{LL}$	para 3-104 (eq 3-41)	$P_e = \frac{(337.51)(43)}{2} \left[\frac{1}{43 + 38 - 3 - 2(7) - 21} \right]$ $= 168.78 \text{ kips} < 799.2 \text{ kips}$ $\therefore P_e = 799.2 \text{ kips}$
43	Floor-beam shear classification	para 3-106 Figures 3-21 through 3-24	<u>One lane:</u> W150 T150 <u>Two lanes:</u> W150 T150

Table F-9. Classification Procedure for a Truss Bridge (continued)

Step	Equation/Procedure	Consideration	Computation	
44	Deck classification	para 3-107 Not critical here.	N/A	
45	Width classification	<i>Table 3-4</i>	<u>One lane:</u> W150 T150	<u>Two lanes:</u> W150 T150
46	Final classification	N/A	<u>One lane:</u> W100 T110	<u>Two lanes:</u> W85 T90

Table F-10. Classification Summary for a Truss Bridge

Classification	W₁	W₂	T₁	T₂
Moment (truss) (step 16)	100	85	110	90
Stringer moment (step 24)	150	150	150	110
Stringer shear (step 30)	150	150	150	150
Floor-beam moment (step 37)	150	150	150	150
Floor-beam shear (step 43)	150	150	150	150
Deck (step 44)	N/A	N/A	N/A	N/A
Width (step 45)	150	150	150	150
Final	100	85	110	90

NOTE: For one-lane bridges, the final classification is the smallest value of the moment, shear, and deck classifications. Post a width-restriction sign if the width classification is smaller than the final classification. For two-lane bridges, the final classification is the smallest value of the moment, shear, width, and deck classifications.

23. Sketches

a. SIDE ELEVATION SCALE 1 SQUARE = None

b. CROSS SECTION OF CRITICAL SPAN SCALE 1 SQUARE = None

c. CROSS SECTION OF CRITICAL MEMBER SCALE 1 SQUARE = None

d. SITE PLAN SCALE 1 SQUARE = None

24. Computation of Bridge Class

NOTES:
Stringers identified as 2 each W21x62 and 5 each W24x94.
Floor beams identified as W36x280.

Additional details on attached sheets.

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Figure F-8. Sample Bridge-Reconnaissance Report for a Truss Bridge

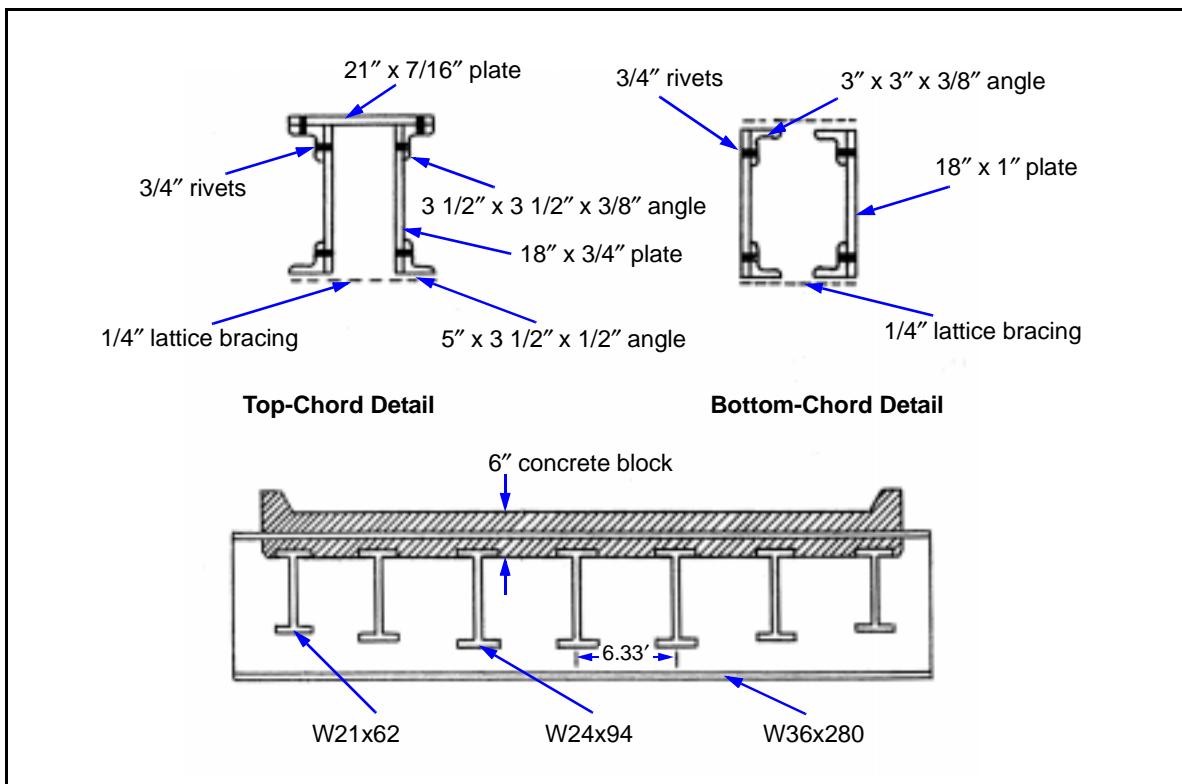


Figure F-9. Truss Details

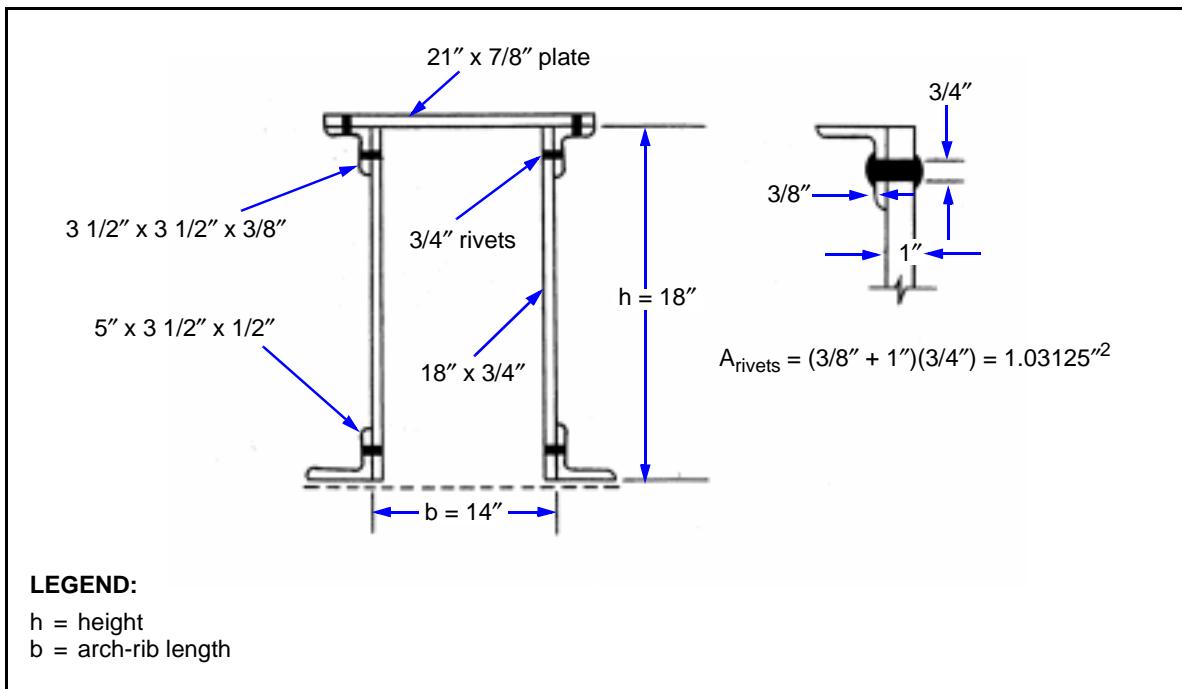


Figure F-10. Rivet Details

REINFORCED CONCRETE-SLAB BRIDGE

F-7. In this example, *Table F-11*, pages F-31 and F-32, shows the procedure for classifying a reinforced concrete-slab bridge and *Table F-12*, page F-32, contains a classification summary. *Figure F-11*, page F-33, shows a sample bridge-reconnaissance report, and *Figure F-12*, page F-34, shows the steel-reinforcement details of this bridge. The local civilian bridge authorities provided the following stress values:

- $F_y = 50 \text{ ksi}$ (grade-50 bars).
- $f'c = 3 \text{ ksi}$.

Table F-11. Classification Procedure for a Reinforced Concrete-Slab Bridge

Step	Equation/Procedure	Consideration	Computation
1	Concrete strength	para 3-132	$f'c = 3 \text{ ksi}$
2	Steel yield strength	para 3-133	$F_y = 50 \text{ ksi}$
3	$A_{st} = \frac{I_2 A_b}{S_b}$ $R_s = \frac{A_{st}}{I_2 d'}$	para 3-134 (eq 3-58, 3-59) $A_b = 1.00 \text{ in}^2$ (for No. 9 bar)	$A_{st} = \frac{(12)(1.00)}{7.5} = 1.6 \text{ in}^2$ $R_s = \frac{1.6}{(12)(12.25)} = 0.011$
4	$d_o = \frac{A_{st}F_y}{10.2f'c}$	para 3-135 (eq 3-60)	$d_o = \frac{(1.6)(50)}{(10.2)(3)} = 2.61 \text{ in}$
5	$m = 0.075A_{st}F_y\left(d' - \frac{d_o}{2}\right)$	para 3-136 (eq 3-61)	$m = (0.075)(1.6)(50)\left(12.25 - \frac{2.61}{2}\right) = 65.67 \text{ kip-feet}$
6	Total dead-load weight of the bridge components	para 3-137 Compute for an average 1-ft length of bridge span.	$W_{DL} = \left(\frac{14}{12}\right)(150)(31.125) + \left(\frac{2}{12}\right)(150)(28) + (2)\left(\frac{14 \times 18}{144}\right)(150) = 6,671.88 \text{ lb/ft}$ $W_{DL} = \frac{6,671.88}{1,000} = 6.67 \text{ kpf}$
7	$m_{DL} = \frac{W_{DL}L^2}{8b_s}$	para 3-137 (eq 3-62)	$m_{DL} = \frac{(6.67)(20^2)}{(8)(31.125)} = 10.72 \text{ kip-feet}$
8	$m_{LL} = \frac{m - 1.3m_{DL}}{1.5}$	para 3-138 (eq 3-63)	$m_{LL} = \frac{65.67 - (1.3)(10.72)}{1.5} = 34.49 \text{ kip-feet}$
9	$b_e = 8 + 0.12L \leq 14 \text{ ft}$	para 3-139 (eq 3-65)	$b_e = 8 + (0.12)(20) = 10.4 \text{ ft}$
10	$M_{LL} = b_e m_{LL}$	para 3-140 (eq 3-66)	$M_{LL} = (10.4)(34.49) = 358.69 \text{ kip-feet}$
11	Moment classification	para 3-141 Appendix B Table B-2 or Figures B-1, B-2 $L = 20 \text{ ft}$	<u>One lane:</u> W75 T50 <u>Two lanes:</u> W75 T50

Table F-11. Classification Procedure for a Reinforced Concrete-Slab Bridge (continued)

Step	Equation/Procedure	Consideration	Computation	
12	Width classification	<i>Table 3-4</i>	<u>One lane:</u> W150 T150	<u>Two lanes:</u> W100 T100
13	Final classification	N/A	<u>One lane:</u> W75 T50	<u>Two lanes:</u> W75 T50

Table F-12. Classification Summary for a Reinforced Concrete-Slab Bridge

Classification	W₁	W₂	T₁	T₂
Moment (step 11)	75	75	50	50
Width (step 12)	150	100	150	100
Final	75	75	50	50

NOTE: For one-lane bridges, use the moment classification and post a width restriction sign if required. For two-lane bridges, the final classification is the smallest value of the moment and width restrictions.

23. Sketches

a. SIDE ELEVATION	SCALE 1 SQUARE = None
Looking northeast	
b. CROSS SECTION OF CRITICAL SPAN	SCALE 1 SQUARE = None
d. SITE PLAN	
c. CROSS SECTION OF CRITICAL MEMBER	SCALE 1 SQUARE = None
See attached sheet	
24. Computation of Bridge Class	
Details of steel reinforcement from as-built drawing shown on attached sheet.	

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SITE PLAN

The site plan shows a location labeled "Sachsendorf" near a stream labeled "Caldwellbach". A road is labeled "AB123456". An arrow indicates "Flow" direction. A north arrow points upwards, labeled "N".

Figure F-11. Sample Bridge-Reconnaissance Report for a Reinforced Concrete-Slab Bridge

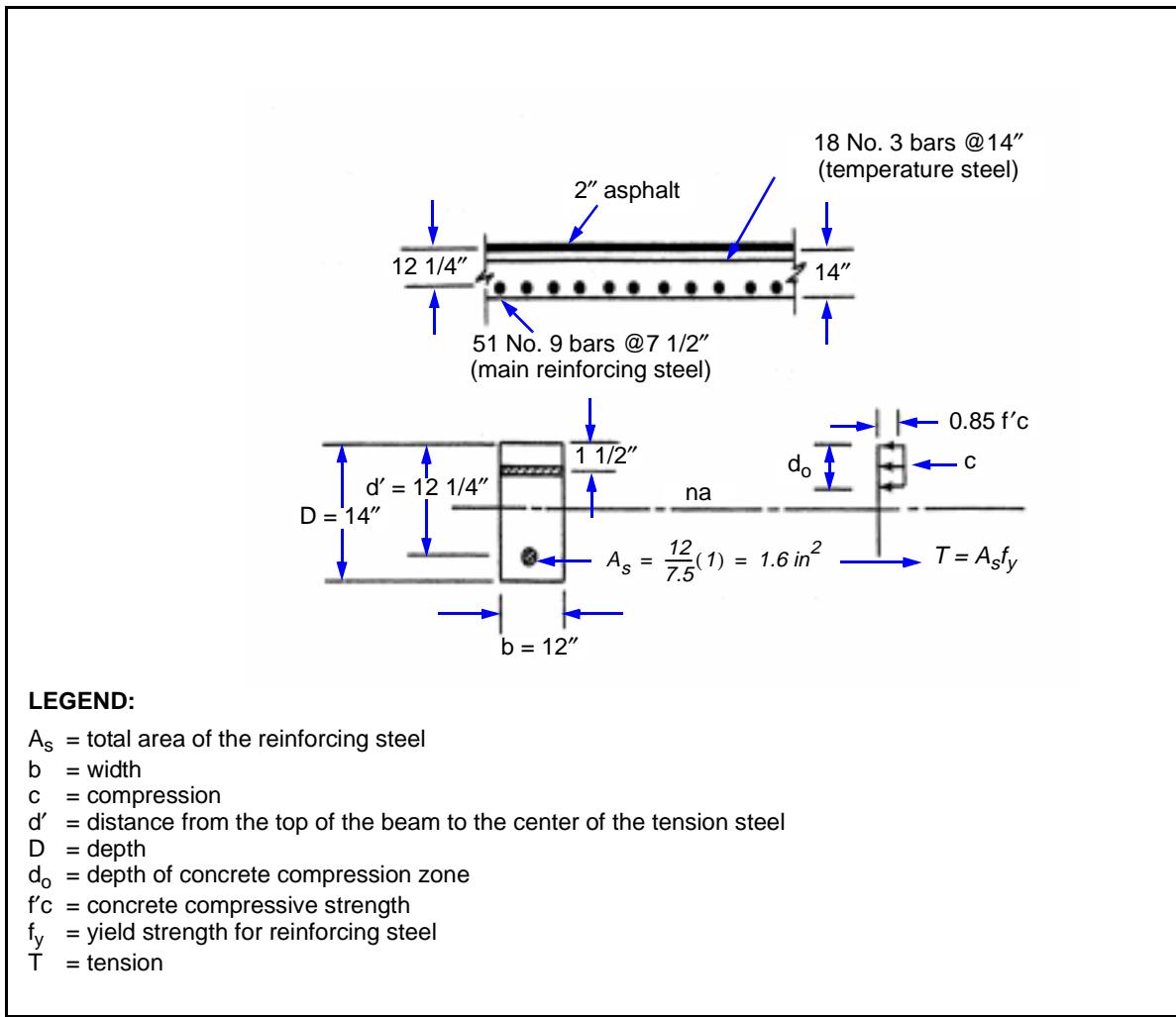


Figure F-12. Steel-Reinforcement Details for a Concrete-Slab Bridge

REINFORCED CONCRETE T-BEAM BRIDGE

F-8. In this example, *Table F-13*, pages F-35 and F-36, shows the procedure for classifying a reinforced concrete T-beam bridge and *Table F-14*, page F-36, contains a classification summary. *Figure F-13*, page F-37, shows a sample bridge-reconnaissance report, and *Figure F-14*, page F-38, shows details of this bridge. The local civilian bridge authorities provided the following stress values:

- $F_y = 40 \text{ ksi}$ (grade-40 bars).
- $f'c = 3 \text{ ksi}$.

Table F-13. Classification Procedure for a Reinforced Concrete T-Beam Bridge

Step	Equation/Procedure	Consideration	Computation
1	Concrete strength	para 3-132	$f'c = 3 \text{ ksi}$
2	Steel yield strength	para 3-133	$F_y = 40 \text{ ksi}$
3	Effective flange width. Lesser value of: $b'' = \frac{I}{4}L$ $b'' = 12t_d + b$ $b'' = S_{T-B}$	para 3-145	$b'' = \frac{I}{4}(50)(12) = 150 \text{ in}$ $b'' = (12)(6) + 16 = 88 \text{ in}$ $b'' = 88 \text{ in}$ $\therefore b'' = 88 \text{ in}$
4	$A_{st} = A_b \times \text{total number of bars in bottom of T-beam}$ $T = A_{st}F_y$	para 3-146 (eq 3-67, 3-68)	$A_{st} = (1.56)(10) = 15.6 \text{ in}^2$ $T = (15.6)(40) = 624 \text{ kips}$
5	$d_o = \frac{A_{st}F_y}{0.85f'c b''}$	para 3-147 (eq 3-69)	$d_o = \frac{(15.6)(40)}{(0.85)(3)(88)} = 2.78 \text{ in} < t_d = 6 \text{ in}$
6	$m = 0.075A_{st}F_y\left(d' - \frac{d_o}{2}\right)$	para 3-148 (eq 3-70)	$m = (0.075)(15.6)(40)\left(41 - \frac{2.78}{2}\right) = 1,853.73 \text{ kip-feet}$
7	Total dead-load weight of the bridge components	N/A	$W'_{DL} = \left[\frac{I}{2}(5)(5) \times 2 + (16)(37.5)\right]\left(\frac{1}{144}\right)$ $(150)(4) + \left(6 \times \frac{I}{12}\right)(150)(28) +$ $\left(2 \times \frac{I}{12}\right)(150)(24) = 5,304.38 \text{ lb/ft}$ $W'_{DL} = \frac{5,304.38 \text{ lb/ft}}{1,000} = 5.30 \text{ kpf}$
8	$w_{DL} = \frac{W'_{DL}}{N_s}$	para 3-29 (eq 3-1)	$w_{DL} = \frac{5.30}{4} = 1.32 \text{ kpf}$
9	$m_{DL} = \frac{w_{DL}L^2}{8}$	para 3-150 (eq 3-75)	$m_{DL} = \frac{(1.32)(50^2)}{8} = 412.5 \text{ kip-feet}$
10	$m_{LL} = \frac{m - 1.3m_{DL}}{1.5}$	para 3-151 (eq 3-76)	$m_{LL} = \frac{1,853.73 - (1.3)(412.50)}{1.5} = 878.32 \text{ kip-feet}$

Table F-13. Classification Procedure for a Reinforced Concrete T-Beam Bridge (continued)

Step	Equation/Procedure	Consideration	Computation
11	Number of effective members	para 3-32 <i>Table 3-3</i>	$S_s = 88 \text{ in} = 7.33 \text{ ft}$: <u>One lane</u> : $N_I = 2.2$ <u>Two lanes</u> : $N_2 = \frac{I_2}{S_s} = \frac{12}{7.33} = 1.64$
12	$M_{LL} = N_{I, 2} m_{LL}$	para 3-152 (eq 3-78)	<u>One lane</u> : $M_{LL} = (2.2)(878.32) = 1,932.30 \text{ kip-feet}$ <u>Two lanes</u> : $M_{LL} = (1.64)(878.32) = 1,440.44 \text{ kip-feet}$
13	Moment classification	para 3-153 <i>Appendix B</i> <i>Table B-2 or</i> <i>Figures B-1, B-2</i> $L = 50 \text{ ft}$	<u>One lane</u> : W120 W85 T90 <u>Two lanes</u> : T65
14	Width classification	para 3-154 <i>Table 3-4</i>	<u>One lane</u> : W150 W60 T150 <u>Two lanes</u> : T60

Table F-14. Classification Summary for a Reinforced Concrete T-Beam Bridge

Classification	W ₁	W ₂	T ₁	T ₂
Moment (step 13)	120	85	90	65
Width (step 14)	150	60	150	60
Final	120	60	90	60
NOTE: For one- and two-lane bridges, the final classification is the smallest value of the moment and width classifications.				

23. Sketches

a. SIDE ELEVATION SCALE 1 SQUARE = None

(Both lanes have identical bridges.)

State Road 294

Concrete abutments

Looking northwest

b. CROSS SECTION OF CRITICAL SPAN SCALE 1 SQUARE = None

2' 24' 2" Asphalt 6"

1.5' 37.5" 88" 16"

c. CROSS SECTION OF CRITICAL MEMBER SCALE 1 SQUARE = None

6" 5" 37.5" 16"

d. SITE PLAN SCALE 1 SQUARE = None

McIntrye 1.6 mi

Thompson 4 mi

Armstrong 13 mi

Karin's Restaurant

Bayless Gas

Potoky 3 mi

Maijan Hwy

US Highway 188

Bishop 8 mi

Goetz 8 mi

Denise's Cash and Carry

AB123456

N

24. Computation of Bridge Class

Details of steel reinforcing on attached sheet.

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Figure F-13. Sample Bridge-Reconnaissance Report for a Reinforced Concrete T-Beam Bridge

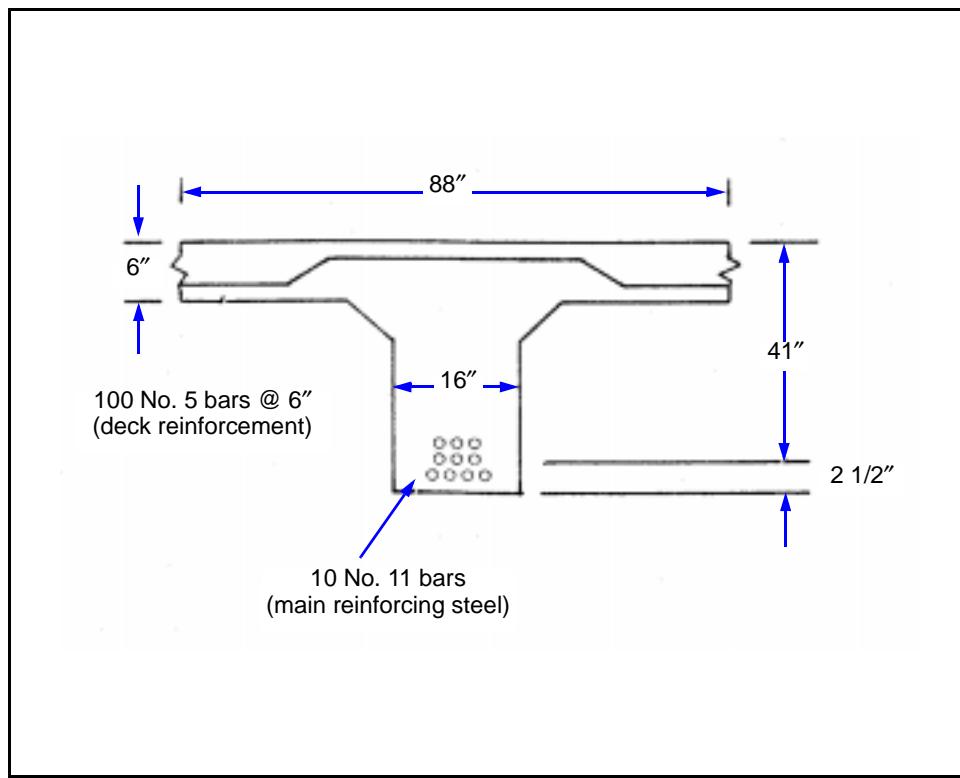


Figure F-14. Steel-Reinforcement Details

REINFORCED CONCRETE-BOX-GIRDER BRIDGE

F-9. In this example, *Table F-15, pages F-39 and F-40*, shows the procedure for classifying a reinforced concrete-box-girder bridge and *Table F-16, page F-40*, contains a classification summary. *Figure F-15, page F-41*, shows a sample bridge-reconnaissance report, and *Figure F-16, page F-42*, shows details of this bridge from as-built civilian drawings. The local civilian bridge authorities provided the following stress values:

- $F_y = 50 \text{ ksi}$ (grade-50 bars).
- $f'c = 4 \text{ ksi}$.

Table F-15. Classification Procedure for a Reinforced Concrete-Box-Girder Bridge

Step	Equation/Procedure	Considerations	Computation
1	Concrete strength	para 3-132	$f'c = 4 \text{ ksi}$
2	Steel yield strength	para 3-133	$F_y = 50 \text{ ksi}$
3	$b'' = \frac{b_f}{N_s}$	para 3-157 (eq 3-79)	$b'' = \frac{(21)(12)}{3} = 84 \text{ in}$
4	$A_{st} = A_b \times \text{total number of bars in bottom of T-beam}$ $T = A_{st}F_y$	para 3-146 (eq 3-67, 3-68) Assume one-third of the bars act with the stem to resist tension.	Three stems, thus divide A_{st} by 3. $A_{st} = \frac{(1.56)(34)}{3} = 17.68 \text{ in}^2$ $T = (17.68)(50) = 884.0 \text{ kips}$
5	$d_o = \frac{A_{st}F_y}{0.85f'c b''}$	para 3-147 (eq 3-69)	$d_o = \frac{(17.68)(50)}{(0.85)(4)(84)} = 3.09 \text{ in}$
6	$m = 0.075A_{st}F_y\left(d' - \frac{d_o}{2}\right)$	para 3-148 (eq 3-70)	$m = (0.075)(17.68)(50)\left(85 - \frac{3.09}{2}\right) = 5,533.40 \text{ kip-feet}$
7	Total dead-load weight of the bridge components	N/A	$W'_{DL} = (71 \times 8 \times 3)\left(\frac{1}{144}\right)(150) + (21 \times 12 \times 7.5)\left(\frac{1}{144}\right)(150) + (29 \times 12 \times 7.5)\left(\frac{1}{144}\right)(150) + (1.5 \times \frac{1}{12})(150)(24) = 6,912.5 \text{ lb/ft}$ $W'_{DL} = \frac{6,912.5 \text{ lb/ft}}{1,000} = 6.91 \text{ kpf}$
8	$w_{DL} = \frac{W'_{DL}}{N_s}$	para 3-29 (eq 3-1)	$W'_{DL} = \frac{6.91}{3} = 2.30 \text{ kpf}$
9	$m_{DL} = \frac{w_{DL}L^2}{8}$	para 3-150 (eq 3-75)	$m_{DL} = \frac{(2.30)(50^2)}{8} = 718.75 \text{ kip-feet}$

Table F-15. Classification Procedure for a Reinforced Concrete-Box-Girder Bridge (continued)

Step	Equation/Procedure	Considerations	Computation
10	$m_{LL} = \frac{m - 1.3m_{DL}}{1.5}$	para 3-151 (eq 3-76)	$m_{LL} = \frac{5,533.40 - (1.3)(718.75)}{1.5} = 3,066.02 \text{ kip-feet}$
11	Number of effective stringers	para 3-32 <i>Table 3-3</i>	$S_s = 10.17 \text{ ft}$: <u>One lane</u> : $N_1 = \frac{16}{S_s} = \frac{16}{10.17} = 1.57$ <u>Two lanes</u> : $N_2 = \frac{14}{S_s} = \frac{14}{10.17} = 1.37$
12	$M_{LL} = N_{I, 2} m_{LL}$	para 3-152 (eq 3-78)	<u>One lane</u> : $M_{LL} = (1.57)(3,066.02) = 4,813.65 \text{ kip-feet}$ <u>Two lanes</u> : $M_{LL} = (1.37)(3,066.02) = 4,200.45 \text{ kip-feet}$
13	Moment classification	para 3-153 <i>Appendix B</i> <i>Table B-2 or</i> <i>Figures B-1, B-2</i> $L = 50 \text{ ft}$	<u>One lane</u> : W150 T150 <u>Two lanes</u> : W150 T150
14	Width classification	<i>Table 3-4</i>	<u>One lane</u> : W150 T150 <u>Two lanes</u> : W60 T60
15	Final classification	N/A	<u>One lane</u> : W150 T150 <u>Two lanes</u> : W60 T60

Table F-16. Classification Summary for a Reinforced Concrete-Box-Girder Bridge

Classification	W ₁	W ₂	T ₁	T ₂
Moment (step 13)	150	150	150	150
Width (step 14)	150	60	150	60
Final	150	60	150	60
NOTE: For one- and two-lane bridges, the final classification is the smallest value of the moment and width classifications.				

23. Sketches

a. SIDE ELEVATION SCALE 1 SQUARE = None

Concrete abutments
Old railroad guide
Looking north

b. CROSS SECTION OF CRITICAL SPAN SCALE 1 SQUARE = None

2' 6"
7.5"
1.5" asphalt
10"
4'
6' 6.5"
21'

c. CROSS SECTION OF CRITICAL MEMBER SCALE 1 SQUARE = None

(See attached sheet)

d. SITE PLAN SCALE 1 SQUARE = None

Seaboard Coastline RR
(Abandoned)
Atomic Boulevard
Orlando 6 mi
Idaho Falls 25 mi
Croydon Road
Jordan 3 mi
Brown's Tree Farm
AB123456
N

24. Computation of Bridge Class

NOTES:
Details of interior from civilian plans shown on attached sheet.
Bridge is in excellent condition.

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Figure F-15. Sample Bridge-Reconnaissance Report for a Reinforced Concrete-Box-Girder Bridge

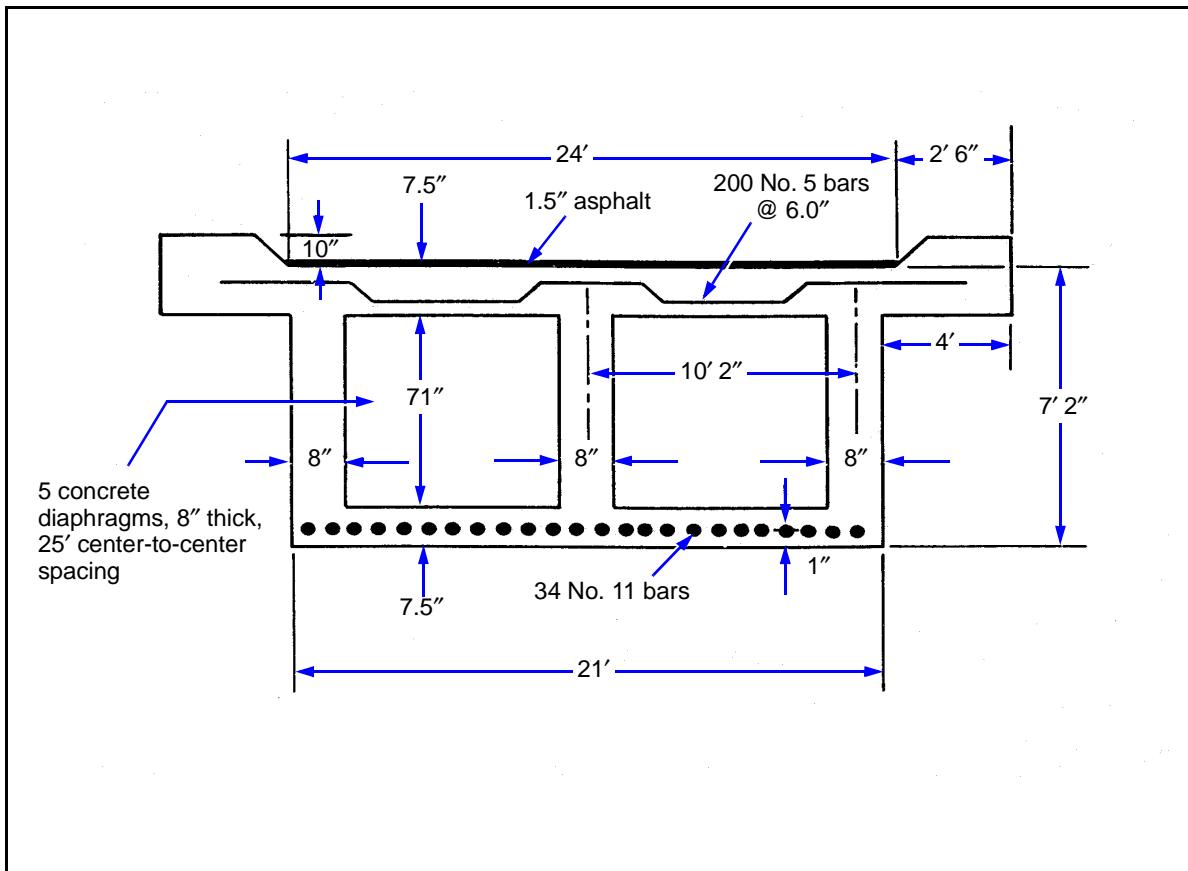


Figure F-16. Details From As-Built Civilian Drawings

PRESTRESSED CONCRETE BRIDGE

F-10. In this example, the bridge deck is of composite construction. Since the 28-day compressive strength of the deck and stringers is the same, no transformed moment of inertia calculations are required. If the deck were made of ordinary-grade concrete and the precast, prestressed beam made of high-strength concrete, the different moduli of elasticity would have to be considered. *Table F-17, pages F-43 through F-45*, shows the procedure for classifying a prestressed concrete bridge, and *Table F-18, page F-45*, contains a classification summary. The detailed dimensions and information about the prestressed steel in *Figure F-17, page F-46*, were taken from as-built drawings. *Figure F-18, page F-47*, shows a sample bridge-reconnaissance report. The local civilian bridge authorities provided the following allowable stress values:

- $f_{pu} = 240 \text{ ksi}$.
- $f'c = 5 \text{ ksi}$.

Table F-17. Classification Procedure for a Prestressed Concrete Bridge

Step	Equation/Procedure	Consideration	Computation
1	Concrete strength	N/A	$f'c = 5 \text{ ksi}$
2	Steel prestress strength	N/A	$f_{pu} = 240 \text{ ksi}$
3	Effective flange width. Lesser value of: $b'' = \frac{l}{4}L$ $b'' = 12t_d + b$ $b'' = S$	para 3-165	$b'' = \frac{l}{4}(75)(12) = 225 \text{ in}$ $b'' = (12)(7) + 26 = 110 \text{ in}$ $b'' = 90 \text{ in}$ $\therefore b'' = 90 \text{ in}$
4	$A_{ps} = A_p \times \text{total number of prestressed bars in bottom half of beam}$ $R_{ps} = \frac{A_{ps}}{b''d_{ps}}$	para 3-166 (eq 3-81)	$A_{ps} = (1.1)(6) = 6.6 \text{ in}^2$ $R_{ps} = \frac{6.6}{(90)(57)} = 0.0013$
5	$A_s = A_b \times \text{total number of prestressed bars in bottom half of beam}$ $R_s = \frac{A_s}{b''d_{ps}}$	para 3-166 (eq 3-82)	$A_s = 0$ $R_s = 0$
6	$R_r = \frac{R_{ps}f_{pu}}{f'c} + \frac{R_s d_s f_{sy}}{d_{ps} f'c}$	para 3-167 (eq 3-83)	$R_r = \frac{(0.0013)(240)}{5} + 0 = 0.0624$
7	$f_{ps} = f_{pu}(1 - 0.5R_r)$	para 3-168 (eq 3-84)	$f_{ps} = (240)[1 - 0.5(0.0624)] = 232.51 \text{ ksi}$
8	$T = A_{ps}f_{ps} + A_s f_{sy}$	para 3-169 (eq 3-85)	$T = (6.6)(240) + 0 = 1,584 \text{ kips}$

Table F-17. Classification Procedure for a Prestressed Concrete Bridge (continued)

Step	Equation/Procedure	Consideration	Computation
9	$A_c = \frac{T}{x_r f'_c}$ <p>where—</p> $x_r = [0.85 - 0.05(f'_c - 4)] \geq 0.65$ <p>for $f'_c > 4.0 \text{ ksi}$</p>	para 3-170 (eq 3-86)	$A_c = \frac{1,584}{(0.8)(5)} = 396 \text{ in}^2$ $x_r = 0.85 - (0.05)(5 - 4) = 0.8$
10	$A_f = t_f b''$	para 3-171 (eq 3-87)	$A_f = (7)(90) = 630 \text{ in}^2$
11	<p>For $R_r \leq 0.3$ and $A_f > A_c$:</p> $d_o = \frac{R_r d_{ps}}{x_r}$ <p>and—</p> $m = 0.075T\left(d_{ps} - \frac{d_o}{2}\right)$	para 3-172 (eq 3-88, 3-89)	$d_o = \frac{(0.0624)(57)}{0.8} = 4.45 \text{ in}$ $m = (0.075)(1,584)\left(57 - \frac{4.45}{2}\right) = 6,507.51 \text{ kip-feet}$
12	Total dead-load weight of the bridge components	N/A	$W_{DL} = \left(1,094 \times \frac{1}{144}\right)(150)(5) +$ $\left(7 \times \frac{1}{12}\right)(150)(34) + \left(2 \times \frac{1}{12}\right)(150)(30)$ $= 9,422.92 \text{ lb/ft}$ $W_{DL} = \frac{9,422.92 \text{ lb/ft}}{1,000} = 9.42 \text{ kpf}$
13	$w_{DL} = \frac{W_{DL}}{N_s}$	para 3-29 (eq 3-1)	$w_{DL} = \frac{9.42}{5} = 1.88 \text{ kpf}$
14	$m_{DL} = \frac{w_{DL}L^2}{8}$	para 3-173 (eq 3-95)	$m_{DL} = \frac{(1.88)(75^2)}{8} = 1,321.88 \text{ kpf}$
15	$m_{LL} = \frac{m - 1.3m_{DL}}{1.5}$	para 3-174 (eq 3-96)	$m_{LL} = \frac{6,507.51 - (1.3)(1,321.88)}{1.5}$ $= 3,192.72 \text{ kip-feet}$
16	Number of effective members	Table 3-3	$S_s = 7.5 \text{ ft}$ <p><u>One lane:</u></p> $N_1 = \frac{14}{S_s} = \frac{14}{7.5} = 1.87$ <p><u>Two lanes:</u></p> $N_2 = \frac{11}{S_s} = \frac{11}{7.5} = 1.47$
17	$M_{LL} = N_{I,2}m_{LL}$	para 3-175 (eq 3-98)	<p><u>One lane:</u></p> $M_{LL} = (1.87)(3,192.72) = 5,970.38 \text{ kip-feet}$ <p><u>Two lanes:</u></p> $M_{LL} = (1.47)(3,192.72) = 4,693.29 \text{ kip-feet}$

Table F-17. Classification Procedure for a Prestressed Concrete Bridge (continued)

Step	Equation/Procedure	Consideration	Computation	
18	Moment classification	para 3-176 <i>Appendix B</i> <i>Table B-2 or</i> <i>Figures B-1, B-2</i> $L = 75 \text{ ft}$	<u>One lane:</u> W150 T150	<u>Two lanes:</u> W150 T135
19	Width classification	<i>Table 3-4</i>	<u>One lane:</u> W150 T150	<u>Two lanes:</u> W100 T100
20	Final classification	N/A	<u>One lane:</u> W150 T150	<u>Two lanes:</u> W100 T135

Table F-18. Classification Summary for a Prestressed Concrete Bridge

Classification	W₁	W₂	T₁	T₂
Moment (step 18)	150	150	150	135
Width (step 19)	150	100	150	100
Final	150	100	150	135
NOTE: For one- and two-lane bridges, the final classification is the smallest value of the moment and width classifications.				

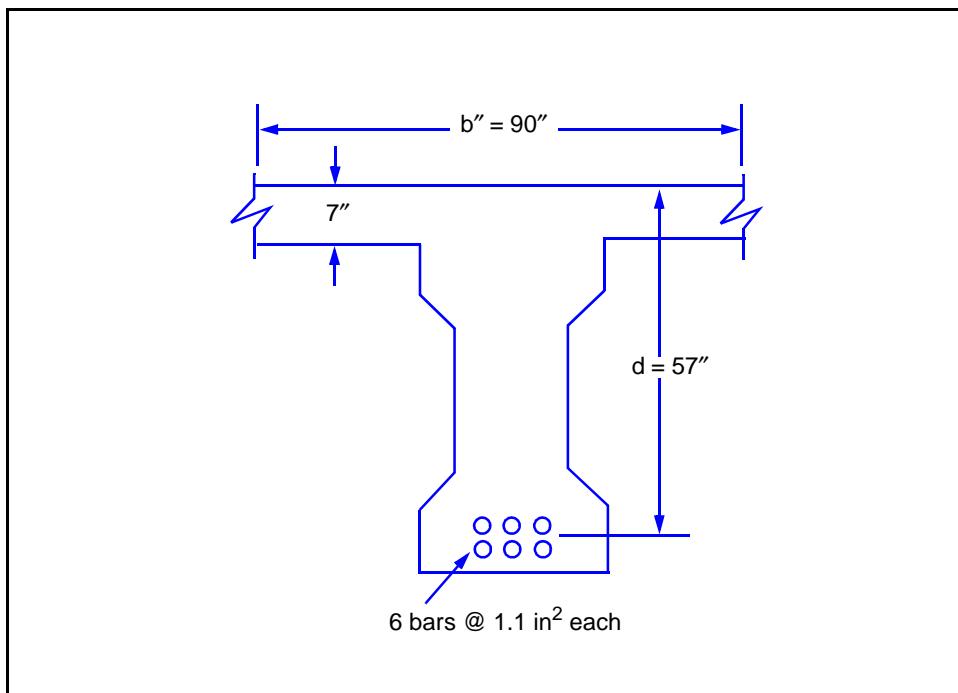


Figure F-17. Details of a Prestressed Beam

23. Sketches

a. SIDE ELEVATION	SCALE 1 SQUARE = None
Concrete abutment	
b. CROSS SECTION OF CRITICAL SPAN	SCALE 1 SQUARE = None
d. SITE PLAN SCALE 1 SQUARE = None	
c. CROSS SECTION OF CRITICAL MEMBER	SCALE 1 SQUARE = None

24. Computation of Bridge Class

NOTES:
Details from civilian drawings on attached sheet.
Bridge is ten years old, but in excellent condition.

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Figure F-18. Sample Bridge-Reconnaissance Report for a Prestressed Concrete Bridge

MASONRY-ARCH BRIDGE

F-11. In this example, *Table F-19* shows the measured bridge dimensions, *Table F-20* shows the classification procedures, and *Table F-21* shows a classification summary for a masonry-arch bridge. *Figure F-19*, page F-50, shows a sample bridge-reconnaissance report. Tests show that the arch is made of blue engineering brick. The ring is in good condition with well-mortared joints (about 3/8-inch wide). A small transverse crack was noted within 2 feet of the edge of the ring and there is a slight vertical settlement at one of the abutments.

Table F-19. Masonry-Arch Dimensions

Bridge Dimensions	
L (ft) (refer to the diagram at right)	40
b _r (ft)	18
b _d (ft)	20
R (ft) (refer to the diagram at right)	20
t _d (in) (do not include the wearing surface) t _d = t + d _f	30

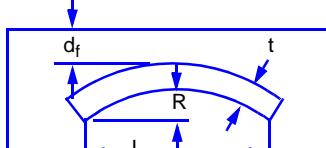


Table F-20. Classification Procedure for a Masonry-Arch Bridge

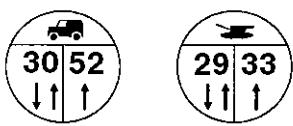
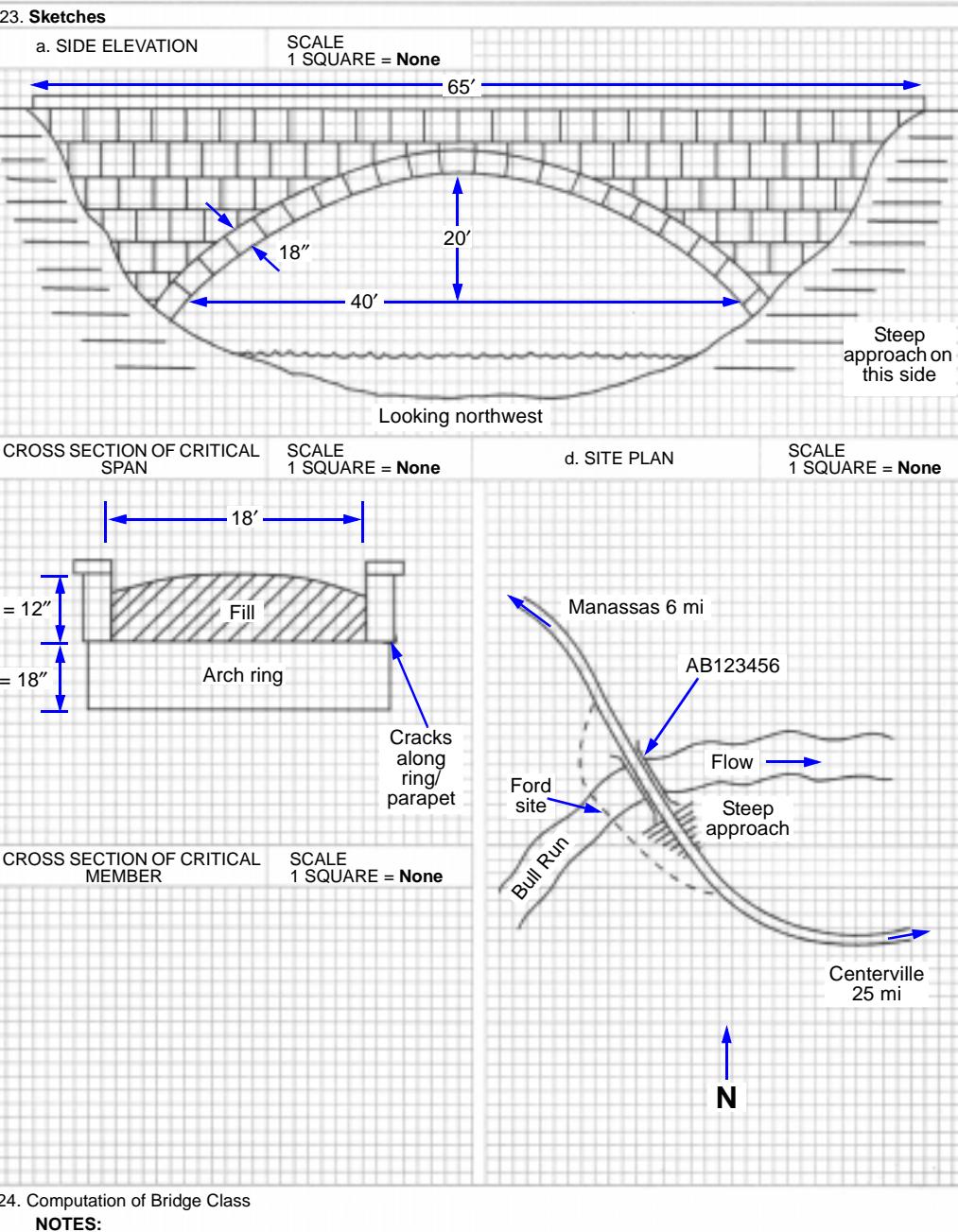
Step	Equation/Procedure	Consideration	Computation
1	PLC	Figure 3-43	PLC = 34
2	Length-to-rise ratio: $\frac{L}{R}$ Arch factors: A (<i>Table 3-13</i>) B (<i>Table 3-14</i>) C (<i>Table 3-15</i>) D (<i>Table 3-16</i>) E (<i>Table 3-19</i>) F (<i>Table 3-17</i>) G (<i>Table 3-18</i>)	Length-to-rise ratio: $\frac{L}{R}$ Arch factors: Profile Material Joint Abutment size Crack Deformation Abutment fault	$\frac{L}{R} = \frac{40}{20} = 2$ Arch factors: A = 1.0 B = Blue engineering brick = 1.2 C = Normal joints, pointed mortar = 1.0 D = Both satisfactory = 1.0 E = Small, transverse crack within 2 feet of the edge = 1.0 F = No significant deformation = 1.0 G = Slight vertical settlement of one abutment = 0.8
3	Strength classification: $T_1 = PLC$ (arch factors) $T_2 = 0.9 T_1$ W_1 W_2	Obtain W_1 and W_2 from Figure 3-45.	$T_1 = (34)(1.0)(1.2)(1.0)(1.0)(1.0)(0.8) = 32.64$ $T_2 = (0.9)(32.64) = 29.38$ $W_1 = 52$ $W_2 = 48$
4	Width classification	<i>Table 3-4</i>	<u>One lane:</u> W150 T150 <u>Two lanes:</u> W30 T30
5	Final classification	See summary in <i>Table F-21</i> .	N/A
6	Posting	Draw a bridge sign.	

Table F-21. Classification Summary for a Masonry-Arch Bridge

Classification	W ₁	W ₂	T ₁	T ₂
Moment (step 3)	52	48	33	29
Width (step 4)	150	30	150	30
Final	52	30	33	29
NOTE: For one-lane bridges, the controlling classification is always the strength classification. Post a width-restriction sign if the width classification is smaller than the strength classification. For two-lane bridges, the controlling classification is the smaller value of the strength and width classifications.				



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Figure F-19. Sample Bridge-Reconnaissance Report for a Masonry-Arch Bridge